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# Thermal analysis of PANSAT electric power subsystem

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# NAVAL POSTGRADUATE SCHOOL
## Monterey, California

# THESIS



THERMAL ANALYSIS OF PANSAT
ELECTRIC POWER SUBSYSTEM

by

Eric L. Victor

June, 1994

Thesis Advisor: I. Michael Ross

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# THERMAL ANALYSIS OF PANSAT ELECTRIC POWER SUBSYSTEM

by


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Submitted in partial fulfillment
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# ABSTRACT

Spacecraft thermal-control subsystems are necessary to maintain all elements of a spacecraft system within their temperature limits for all mission phases. In most instances the heat inputs are highly variable with time, requiring thorough transient-analysis of thermal flow within the spacecraft. Additionally, steady-state thermal profiles are necessary for precise overall thermal-analysis. The objective of this thesis is to develop a steady-state thermal model of the Electric Power Subsystem (EPS) and its associated housing for the Petite Amateur Navy Satellite (PANSAT). This task is undertaken to identify any physical locations within the EPS where temperatures exceed the limits established to protect sensitive electronic components. Software generated steady-state analysis using only contact-conductances for the EPS through the housing attachment is performed. It is shown that given the geometry of the physical model, the conductive relations developed, and the given boundary conditions, the steady-state temperature of the EPS and its associated housing will remain within limits.

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# I. INTRODUCTION

In order to maintain all the elements of a spacecraft system within their temperature limits for all mission phases, thermal analysis of individual spacecraft subsystems is necessary for thermal-control subsystem design. Thermal-control designers must account for heat inputs from several sources, such as the Sun, the Earth, and electrical and electronic components on-board the spacecraft. In most instances the heat inputs are highly variable with time, requiring thorough transient-analysis of thermal flow within the spacecraft. Additionally, steady-state thermal profiles are necessary for overall thermal analysis. During the preliminary mission design of a spacecraft there are several thermal issues which must be addressed. A review of these issues bounds the thermal design problem. The first step in the thermal design of a spacecraft is to determine key requirements and constraints, which include the temperature limits and power dissipation of all spacecraft components. Next, spacecraft altitude and orientation relative to the Earth and Sun for all mission phases is determined in order to calculate the minimum and maximum thermal flux from each of these celestial bodies. With this, environmental heat inputs on the exterior surfaces of the spacecraft can be calculated. Once thermal boundary conditions are established, temperature limits defined, software modeling developed, and any other miscellaneous requirements understood, a complete spacecraft thermal subsystem can be developed.

## A. THESIS SCOPE

The purpose of this thesis is to develop a steady-state thermal model of the Electric Power Subsystem (EPS) and its associated housing for the Petite Amateur Navy Satellite (PANSAT). This task is undertaken in order to identify any physical locations within the EPS where temperatures exceed the limits established to protect sensitive electronic components. Software generated steady-state analysis using only contact conductances through the housing attachment is studied to pinpoint any physical locations that deviate from the allowable temperature ranges. To generate the data needed for analysis it was necessary to determine circuit board layouts, which

included component locations and board sizes, in addition to power dissipation requirements of individual components. From this information, thermal nodes and thermal conductivities between nodes were calculated. Inward-viewing box geometry was created to physically model the EPS. Finally, the EPS housing was sized for thickness and structural integrity for a dynamic environment with an emphasis on thermal concerns.

## B. BACKGROUND

A basic understanding of thermal conductivity and of the Integrated Thermal Analysis System (ITAS) software used to thermally model the EPS is necessary to appreciate the scope of this thesis.

### 1. Heat Conduction

#### *a. Conduction*

Whenever a temperature gradient exists in a solid medium, heat will flow from the higher-temperature to the lower-temperature region. The rate at which heat is transferred by conduction is proportional to the temperature gradient multiplied by the area of flux through which heat is being transferred:

$$q = A\frac{dT}{dx} \tag{1}$$

The actual rate of heat flow depends on the thermal conductivity, k, which is a physical property of the medium. For conduction through a homogeneous medium, the rate of heat transfer is then:

$$q = -kA\frac{dT}{dx} \tag{2}$$

The minus sign is included as a result of the second law of thermodynamics which requires that heat must flow from a higher-temperature region to a lower-temperature region. Equation (2) provides the definition for the thermal conductivity, k, and is called Fourier's Law of Conduction in honor of the French scientist J.B.J. Fourier, who proposed it in 1822. The thermal conductivity is a material property that indicates the amount of heat that will flow per unit time across a unit area when the temperature gradient is unity. Although, in general, the thermal conductivity varies

with temperature, in many engineering problems the variation is sufficiently small to be neglected. For engineering calculations, experimentally measured values of thermal conductivity are used [Ref. 1: p 4-8]

The best thermal conductors are metallic solids and the poorest ones are gases. In between lie alloys, nonmetallic solids, and liquids. Solid materials consist of free electrons and of atoms in a periodic lattice arrangement. Thermal energy may thus be conducted by two mechanisms: migration of free electrons and lattice vibration. These two effects are additive, but, in general, the transport due to electrons is more effective than the transport due to vibrational energy in the lattice structure. Since electrons transport electric charge in a manner similar to the way in which they carry thermal energy from a higher-temperature region to a lower-temperature region, good electrical conductors are usually also good heat conductors and good electrical insulators are poor heat conductors. In non-metallic solids there is little or no electronic transport and the conductivity is therefore primarily determined by lattice vibration. This explains why these materials have a lower thermal conductivity than metals. An important group of solid materials for heat transfer design are thermal insulators. These materials are solids, but their structure contains air spaces that are sufficiently small to suppress gaseous motion and thus take advantage of the low thermal conductivity of gases in reducing heat transfer. Although we usually speak of a thermal conductivity of thermal insulators, in reality the transport through an insulator is comprised of conduction as well as radiation across the interstices filled with gas. In good insulators the spaces containing the air are sealed from each other, as in cellular foams made from plastic or glass. The thermal conductivity value of insulation systems is always an effective value that accounts for conduction, radiation, and sometimes also convection within the material. [Ref. 1: p. 10-12]

***b. Thermal Conductance***

To establish the working equation for thermal conductance that will be used in calculations for this thesis, examine the simple case of steady-state heat flow through a plane wall with a non-varying temperature gradient and non-varying heat flow through a uniform cross-sectional area. Using these assumptions and integrating equation (2) we obtain:

$$q = \frac{T_{hot} - T_{cold}}{L / Ak} \qquad (3)$$

In this equation, ($T_{hot}$ - $T_{cold}$), the difference between the higher-temperature region and the lower-temperature region is the driving potential that causes the flow of heat. The quantity (L/Ak) is equivalent to a thermal resistance, R, that the theoretical wall offers to the flow of heat by conduction, thus:

$$R = L / A k \qquad (4)$$

The reciprocal of the thermal resistance is referred to as the thermal conductance, K, defined by: [Ref. 1: p. 6,7]

$$K = A k / L \qquad (5)$$

*c. Contact Resistance*

When different conducting surfaces are placed in contact, a thermal resistance is present at the interface of the solids. The interface resistance, frequently called the contact resistance, is developed when two materials will not fit tightly together and a thin layer of fluid is trapped between them. Examination of an enlarged view of the contact between two surfaces shows that the solids touch only at the peaks in the surface and that the valleys in the mating surfaces are occupied by a gas (possibly air), a liquid, or a vacuum. The following parameters are of primary importance:

- Geometry of the contacting material: surface roughness
- Thickness of the gap
- Type of interstitial fluid: gas, liquid, grease, vacuum
- Thermal conductivities of materials
- Microhardness of surface materials
- Contact pressure
- Apparent contact area
- Temperature

At the interface, the mechanism of heat transfer is complex. Conductance takes place through the contact points of the solids, while heat is transferred by convection and radiation across the trapped interstitial fluid. [Ref. 1: p. 12]

It is difficult to determine the surface quality of a material. Surface qualities include its geometry, crystal structure, appearance, color, resistance to corrosion, hardness (microhardness), and size and shape of surface flaws. The surface deviations determine the surface roughness. There are three types of surface deviations: surface flaws, waviness, and roughness. Surface flaws are occasional irregularities; waviness consists of widely spaced irregularities such as feed marks; and roughness consists of finely spaced irregularities (less than 1/32 in.) which determine the 'finish' of a surface. The average height of surface irregularities is a measure of roughness but not a complete specification of the character of the irregularities. A preferred set of roughness classes has been suggested from 1/4 in. to 63,000 microin., as average. [Ref. 2: p.13-65]

Hardness of materials has been variously defined as resistance to local penetration, to scratching, to machining, to wear or abrasions, and to yielding. The multiplicity of definitions and corresponding multiplicity of hardness measuring instruments, together with the lack of a fundamental definition, indicates that hardness may not be a fundamental property of a material but rather a composite one including yield strength, work hardening, true tensile strength, modulus of elasticity, and others. The resistance to localized penetration, or indentation hardness, is widely used industrially as a measure of hardness and is the one measure used for this thesis.[Ref. 2: p.5-15]

There are several indentation tests commonly utilized. The Brinell hardness is determined by forcing a hardened sphere under a known load into the surface of a material and measuring the diameter of the indentation left after the test. The Brinell hardness number is obtained by dividing the load used, in kilograms, by the actual surface area of the indentation, in square millimeters. The result is a pressure, but the units are rarely stated. In the standard Brinell test, the diameter of the impression is measured with a low-power hand microscope, but for production work there are available several testing machines which automatically measure the depth of the impression and from this give readings of hardness.

In the Rockwell method of hardness testing, the depth of penetration of an indentor under certain arbitrary conditions of test is determined. The indentor may be either a steel ball of some specified diameter or a spherical-tipped conical diamond of 120 deg. angle and 0.2 mm tip

radius, called a "Brale". A minor load of 10 kg is first applied which causes an initial penetration and holds the indentor in place. Under this condition, the depth-measuring scale is set to its arbitrary maximum value of 130 if any of the balls are used, or to 100 if the Brale is used. A major load of 60 100, or 150 kg is then applied under dashpot control and then removed, returning to the minor load of 10 kg. The hardness number may then be read directly from the scale which measures penetration, and this scale is so arranged that soft materials with deep penetrations give low-hardness numbers. As compared with the Brinell test, the Rockwell method makes a smaller indentation, may be used on thinner material, and is much more rapid since hardness numbers are read directly and need not be calculated. The relation among the scales of various hardness methods is not exact, since no two measure exactly the same sort of hardness, and a relationship determined on steels of different hardnesses is only approximately true with other materials. The Brinell-Rockwell relation is fairly satisfactory and is shown in Figure 1. [Ref. 2: p. 5-16]

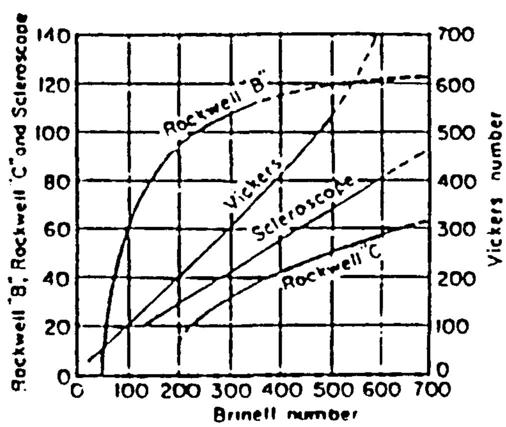



**Figure 1. Hardness Scales**

*d. Joint Conductance*

What follows in this section is based on work in thermal contact by Professor M.M. Yovanovich of the University of Waterloo, in Waterloo, Ontario.

Once the microhardness, H, the thermal conductivity, k, and surface roughness, $S_r$, are determined for both surfaces, and interstitial fluid trapped between the two surfaces, if any, is identified, we can proceed with calculations to determine the joint conductance. Additional

information required includes the contact pressure of the surfaces, P, the apparent contact area of the two surfaces, $A_a$, and temperature of the surfaces. We define the joint conductance, h, as follows with $h_c$ being the contact conductance and $h_g$ being the gap conductance:

$$h = h_c + h_g \qquad (6)$$

(1) Contact Conductance. The first step in calculating the contact conductance is to determine the mean thermal conductivity, $k_s$, of the two surfaces:

$$k_s = \frac{2(k_1)(k_2)}{k_1 + k_2} \qquad (7)$$

The hardness of the softer material is then utilized to find P/H. The value for P/H and the measured readings for surface roughness of the materials are input into the following equation which is then solved for $h_c$, the contact conductance:

$$h_c = \frac{(1.25)k_s[P / H]^{.95}}{S_r} \qquad (8)$$

(2) Gap Conductance. For a complete explanation and derivation for the gap conductance, refer to works by Professor Yovanovich. For the purposes of this thesis, the interstitial space is assumed to be a vacuum and $h_g$, the gap conductance, is assumed to be zero.

**2. Integrated Thermal Analysis System**

The Integrated Thermal Analysis System (ITAS) was developed by the Analytix Corporation in 1988. ITAS was developed to assist spacecraft designers in all tasks in thermal design modeling from geometry generation to results post-processing for various engineering computations. These computations include orbital analysis, thermal analysis, contamination evolution, plume impingement, etc. The current interactive version of the code fully supports all capabilities relevant to the spacecraft thermal analysis, namely, view factors (contour integration and ray tracing), shadow factors (blockage), on-orbit incident flux determination for various orientations, radiation interchange factors, on-orbit absorbed heat-rates calculations in addition to steady-state and/or transient temperature computations. There are other capabilities that may be reviewed in the ITAS Users Manual and are not discussed further here.

ITAS is an integrated, interactive, and fairly user-friendly code. Once started, the user may select various options from well designed color menus, depending on the purpose, to calculate or plot various parameters interactively. No special compiler or linker program is necessary to run ITAS, which simplifies the loading and running of the main program. No in-depth knowledge of DOS is required, although an understanding of the basic concepts of heat transfer is necessary for some user provided calculations.

Utilizing ITAS begins with generation of the geometric model. ITAS may be used to interactively generate surface geometry models from "primitives" (basic shapes). These shapes include polygons, boxes, disc's, cones, cylinders, paraboloids, spheres, any generic surface of revolution, generic boxes of any cross-section, and elbows of any angle. All shapes generated are stored in a file called a PARTS file. A PARTS file may consist of 1000 or more parts (the number of parts is limited only by the available disc space) and any number of parts may be chosen for building a geometric model. The parts generated may then be selectively plotted for model building. Once a model is displayed on the screen, surface node numbers and user-assigned thermal node numbers are assigned to the active surfaces in the geometric model.

Once the geometric model is built and surface nodes generated, material properties may be assigned to each surface or node via a reference number from the internal ITAS material property library. Two sets of material property libraries may be accessed from within the ITAS: the optical characteristics library and the physical property library.

The optical library currently contains about four hundred solar absorbtivity and emissivity pairs for coatings and other surfaces and their finishes from white paint to many variations of metallic surfaces. The optical property library may be accessed from different locations within the program, enabling the user to utilize the information within without leaving the main routine. When a material I.D. is entered for a particular surface, the program will automatically assign those optical properties to the surface for all calculations. The contents of the library may be updated by the user.

The physical property library provides information-only data to the user. There are over eleven hundred material entries in this library. The following material properties may be obtained

from this database: thermal conductivity, specific heat, density, latent heat, and maximum or transition temperatures of a specific material. Some of these values are later used in calculations for conductive relationships. Once the geometric model with ITAS generated surface nodes and their associated material properties are entered, then user-defined nodes are entered by the user.

User-nodes are non-geometric nodes and, therefore, do not have any "physical" presence (surface) in ITAS. These nodes are used for mathematically connecting all the surfaces in the geometric model and any other surfaces the user desires. Three types of thermal nodes are allowed in ITAS. First, Diffusion nodes are nodes with finite masses; Second, a Boundary node is a node where the temperature remains fixed at all times; Third, an Arithmetic node is a node with zero mass. The temperature response of an Arithmetic node is instantaneous. Arithmetic nodes exist mathematically in ITAS only, not as physical nodes.

When all user-nodes are entered, conductive values must be calculated and entered for nodal connections. Except for some specialized situations, all conductance values must be pre-calculated by the user. The current version of ITAS will not automatically calculate the conductance between the nodes.

The preceding paragraphs represent the minimum required tasks to be completed in order to execute an ITAS run. Other options are available with the problem dictating option usage.

# II. THERMAL MODEL

## A. MATERIAL

In order to create the thermal model, the materials for all components and structures must be selected, as well as their geometry. Judicious selection of nodes must be made as well as the following thermal model material parameters determined. [Ref. 3: p. 435]

- Strength
- Stiffness.
- Density (weight)
- Thermal conductivity
- Thermal expansion
- Corrosion resistance
- Cost
- Fracture toughness
- Ease of fabrication
- Versatility of attachment options
- Availability

In addition to the above mentioned mechanical and thermal properties of spacecraft materials, there are other properties of note such as ductility, brittleness, creep, and fatigue strength.

Ductility measures the capacity of a material for inelastic deformation without rupture. Brittleness indicates little capacity for plastic deformation without failure. Ductility is measured by the percentage elongation of tensile test specimen after failure for a specified gauge length. Usually, a material having less than 5% elongation at fracture is said to be brittle and one having more is said to be ductile.

Creep is defined as the time-dependent deformation of a material under an applied load. It is usually regarded as an elevated temperature phenomenon, although some materials also creep at room temperature. The results of tests of materials under a constant load and temperature are usually plotted as strain versus time up to ruptures. The plotted curve exhibits three distinct regions. The first stage includes both elastic and plastic deformities. This stage shows a decreasing creep rate which is due to the strain hardening. The second stage shows a constant minimum creep rate caused by the annealing effect. In the third stage, a considerable reduction in the cross-sectional area occurs, resulting in an increase in stress and creep rate which eventually leads to fracture.

In a tensile test, the load is applied gradually to the failure. Such load condition is known as static condition. A spacecraft is subjected to both static and dynamic loads. In a dynamic load, the stresses are repeated a large number of times, the actual maximum stress is below the ultimate strength of the material and quite frequently even below the yield strength. Such failures are called fatigue failures.

A fatigue failure starts with a small crack. Once a crack has developed, the stress concentration effect becomes greater and the crack progresses more rapidly. As the stress area decreases in size, the stress increases in magnitude until the part fails suddenly. The failure is similar to brittle material fracture.

For ferrous materials, the strength under repeated stresses is often referred to as the endurance limit. Endurance limit stress is the stress that can be repeated an infinite number of times without causing the fracture of the material. Nonferrous materials, such as aluminum alloys, do not have an endurance limit, as they continue to weaken when the stress cycles are repeated. Hence the fatigue strength is the maximum stress that can be repeated for specified number of cycles without producing the failure of the unit.

Stress concentration may be caused by any discontinuity, such as holes, notches, and any abrupt changes in the cross section. Under steady loads, the effect of stress concentration is reduced due to the redistribution of the stresses in the region of the stress concentration, resulting from the plastic flow of the material when the maximum stress reaches the yield point. The effect

of the stress concentration on the brittle material, under a steady load, may be severe since very little plastic flow occurs. Under repeated loads, however, the endurance strength of even ductile material may be greatly reduced due to stress concentration. [Ref. 4: p. 244-248]

### 1. Material Selection

For structural and component housing designs, the engineer must consider optional materials, types of structures, and construction methods by performing trade studies to compare weight and cost. Most metals are very nearly homogeneous, having constant properties throughout their composition, and isotropic, having the same properties regardless of direction. Non-metals are usually formed with composites, or blends of more than one material. Composite materials can be homogeneous or isotropic, but not generally.

#### *a. EPS Housing*

By far the most commonly used metallic material for spacecraft structures and housings is aluminum, of which there are many types and tempers. Aluminum is lightweight, strong, and readily formable. Aluminum and its alloys, numbering in the hundreds, are available in all common commercial forms. The metal does not oxidize progressively because, when exposed to air, a hard, microscopic oxide coating forms on the surface that seals the metal from the environment. The tight chemical bond of oxide is the reason that aluminum is not found in nature; it exists only as a compound.

Aluminum-alloy sheet can be formed, drawn, stamped, or spun. Many wrought or cast aluminum alloys can be welded, brazed, or soldered, and aluminum surfaces readily accept a wide variety of finishes, both mechanical and chemical. Because of their high electrical conductivity, many aluminum alloys are used as electrical conductors. Aluminum reflects radiant energy throughout the entire spectrum, is non-sparking, and non-magnetic.

Commercially pure aluminum has a tensile strength of about 13,000 psi. Cold-working the metal approximately doubles its strength. For greater strength, aluminum is alloyed with other elements such as manganese, silicon, copper, magnesium, or zinc. Like pure aluminum, the alloys can also be strengthened by cold-working. Some alloys are further strengthened and

hardened by heat treatments At subzero temperatures, aluminum is stronger than at room temperature and is no less ductile. Most aluminum alloys lose strength at elevated temperatures, although some retain significant strength to 500 deg. F. [Ref. 5: p. 48]

For this thesis, Aluminum 6061-T6 was chosen for the EPS housing material. It is a wrought aluminum-alloy containing 61% aluminum, or alloy purity, designated by the third and fourth digits, with a combination of magnesium and silicon as the major alloying elements. The T6 suffix in the designation number indicates that the alloy was solution-heat-treated and artificially aged.

### *b. Printed Circuit Boards*

The printed circuit boards consist of six-layers with alternating levels of copper as the conductor and polyimide as the insulator, as shown in Appendix A. The copper is exposed on the bottom of the printed circuit board and the polyimide is exposed on the top of the circuit board. The top layer of polyimide is 'scratched' to allow for the uppermost layer of copper to be utilized as the signal layer for the components placed on the circuit board. The ground-layer of copper is the fourth layer from the top with the bottom layer of copper acting as the thermal plane.

Copper and copper alloys are fabricated in rod, plate, strip, sheet, tube shapes, forgings, wire, and castings. These alloys are grouped according to composition into several general categories: coppers, high-copper alloys, brasses, leaded brasses, bronzes, aluminum bronzes, silicon bronzes, copper nickels, and nickel silvers. Copper and its alloys form adherent films that are relatively impervious to corrosion and that protect the base metal from further attack. The copper alloys are used where any of the following properties are needed: good thermal or electrical conductivity, corrosion-resistance, ease of forming, ease of joining, and color. On a volume basis, copper has the highest conductivity of any commercial metal. On the other hand, copper and its alloys have relatively low strength-to-weight ratios and low strengths at elevated temperatures. Some alloys are susceptible to stress-corrosion cracking unless they are stress relieved. Copper and its alloys can be hot or cold-worked, although they work-harden. Ductility can be restored by annealing or in heating incident to welding or brazing operations. For our printed circuit board application as well as any application requiring maximum thermal or

electrical conductivity, the most widely used copper is C11000, known as "tough pitch" which contains approximately .03% oxygen and a minimum of 99.9% copper. [Ref. 5: p. 52]

As already stated, polyimide was utilized for printed circuit board fabrication. Polyimides are a family of some of the most heat and fire-resistant polymers known. Their excellent retention of mechanical and physical properties at high temperatures is due to the nature of the aromatic raw materials that are building blocks of polyimides.

Polyimides are formulated as both thermosets, and thermoplastics. Moldings and laminates are generally based on thermoset resins, although some are made from thermoplastic grades. Unlike most plastics, polyimides are available as laminates and shapes, molded parts, and stock shapes. Thin-film products such as enamel, adhesives, and coatings are usually derived from thermoplastic polyimide resins.

Laminates are based on continuous reinforcements including woven glass and quartz fabrics, or fibers of graphite, boron, quartz, or organic materials. Molding compounds contain discrete fibers such as chopped glass or asbestos, or particulate fillers such as graphite powder, MoS2, or PTFE.

Polyimide laminates can operate continuously in air at 500 °F; service temperature for intermittent exposure can range from cryogenic to as high as 900 °F. Glass-fiber-reinforced versions retain over 70% of their flexural strength and modulus at 480°F. Creep is almost nonexistent, even at high temperatures, and deformation under load (4,000 psi) is less than .05% at room temperature for 24 hours. These materials have good wear resistance and low coefficients of friction, both of which are further improved by PTFE fillers. Electrical properties of polyimide laminates are outstanding over a wide range of temperature and humidity conditions. [Ref. 5: p. 115]

## B. GEOMETRY

### 1. EPS Housing

The EPS housing encases the Electrical Power System and is located on the -Y side of the upper equipment plate. The EPS will have a maximum mass of 5 lbm. the EPS must remain statically and dynamically within the mounting envelope. Thus, the thickness of the EPS walls must be calculated so as to meet these design criteria. Mounting of the EPS to the upper equipment plate will be by means of stainless steel screws into the upper equipment plate. The EPS housing is to have a mounting surface which is to contact the lower side of the equipment plate with a required flatness to within .002 in. over its length and width. The actual dimensions of the EPS, as well as the EPS housing location within PANSAT, are shown in Appendix B.

The EPS housing is thermally modeled in the ITAS system as a 6-sided box with the dimensions of 9 in. in the X-direction, 8 in. in the Y-direction, and 1.569 in. in the Z-direction. For more precise mathematical construction, the +Y and -Y sides of the EPS housing were divided into four distinct physical and mathematical nodes. This geometry is shown in Figure 2.

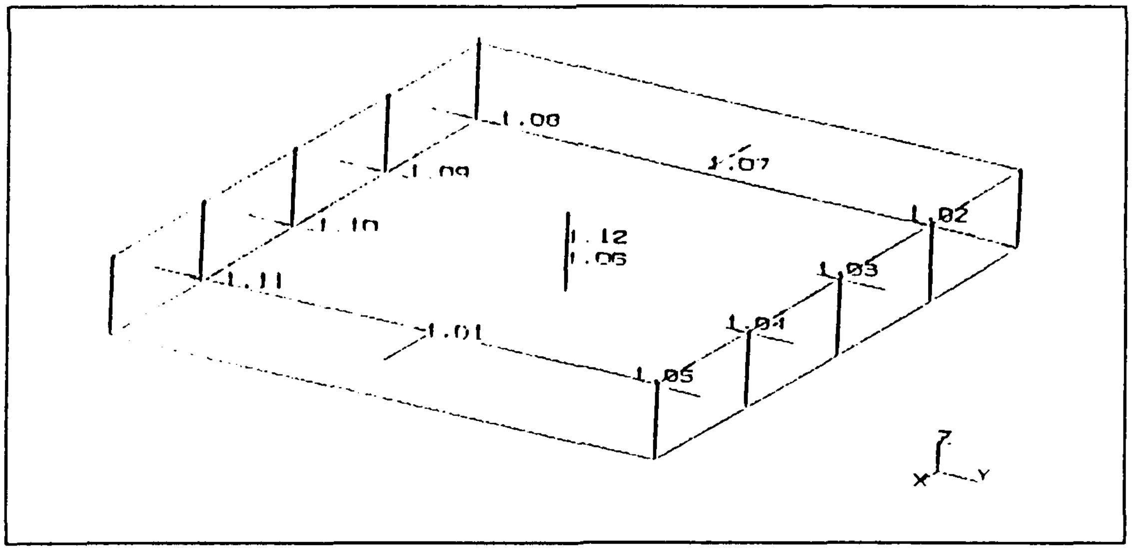



**Figure 2. EPS Housing and Nodes**

As can be seen in the figure, this results in the EPS housing having 12 physical nodes. It should be noted that these 12 nodes represent the inside-surfaces of the EPS housing since this thesis is concerned only with the inward-viewing geometry. Outside surface nodes would be

required if it were necessary to calculate the radiant thermal flux from other spacecraft components.

### 2. Printed Circuit Boards

There were several questions to address in the modeling of the printed circuit boards. The first question was whether or not to model the two circuit boards within the EPS as one-sided or two-sided for purposes of ITAS calculated view factors. The second question dealt with the determination of the number of physical nodes each circuit board would require for precise measurements. Once the number of nodes were determined, in what shapes would these nodes be? Lastly, once the overall thickness of the circuit boards was determined, how would each layer of a circuit board be modeled in relation to the other layers of the same board?

It was determined that for the most accurate measurements, the circuit boards would be modeled as 2-sided for view-factor and shadow-factor computations. After examination of both the upper and lower circuit board layouts and the power dissipation for each component on each board, a physical breakdown into nodes was completed. The printed circuit board layouts, power dissipation requirements, and nodal breakdowns for both boards can be found in Appendix A. The upper circuit board was modeled as two separate polygons with a total number of 18 physical nodes while the lower board was modeled as a single polygon and divided into 12 physical nodes. Nodal breakdowns for both boards was based on attempting to maximize the number of nodes for the sake of accuracy, while striving to minimize the number of nodes for sake of convenience and ease of calculation. These two somewhat contradictory approaches yielded the results shown. For both circuit boards, all physical nodes were rectangular, a construct which greatly reduces the number of user calculations.

The overall thickness of both circuit boards was determined to be .062 in. The copper layers were of the 1 ounce type which means that the thickness would be that of 1 ounce of copper over a 1 sq. ft. area. Using the density of copper at 20 °C, yielding 8.96 g/cm$^3$, and converting to oz/ft$^3$ resulted in a density of 8,949 oz/ft$^3$. Solving for the volume, and thus the thickness:

$$t = \frac{M}{DLW} = \frac{1oz}{(8949oz / ft^3)(1ft)(1ft)} = .00011 ft$$

$$t = .00134 \text{ in.}$$

This is the thickness for one layer of the copper. Multiplying by 3 yielded the thickness for all copper layers. Subtracting this from .062 and dividing that number by 3 yielded a thickness for each polyimide layer of .01933 in. These thicknesses will be used later in calculation of flux areas for thermal conductivity between nodes.

For the modeling of the circuit board layers, each layer was given the identical geometry. For the top printed circuit board, the bottom layer of thermal plane copper was numbered from 601 to 618 with next layer up being a polyimide layer with node numbers of 501 to 518. This numbering system was continued with each subsequently higher layer numbering in the 400's, 300's, 200's, and 100's. This same numbering technique was used in the bottom board as well with the layers numbered from the 1600's to 1100.

## C. THERMAL NODES

### 1. Node Definitions

Appendix C contains a listing of all ITAS generated surface numbers and the user-generated node numbers that were assigned to them. These user node assignments are made in order to create a mathematical node for each surface for thermal calculations. All EPS housing thermal nodes were given 900 series numbers, from 901 to 912. Node no. -913 was input as the thermal node for the bottom of the upper equipment plate. Thus, the EPS housing-PANSAT thermal interface will be between the 906 and -913 nodes. Recall that the minus sign in front of 913 indicates that particular node will have a constant temperature.

In addition to the physical nodes that were created geometrically in ITAS, several more mathematical nodes were created in order to more effectively model the overall system. The inside geometry of the model can be seen in Appendix D. What this will show is a simple line schematic of a box with two flat (thin) surfaces representing the printed circuit boards. This model is constructed this way, as mentioned earlier, to calculated the view and shadow factors internal to

the EPS. However, the actual physical contact between the printed circuit boards and the housing occurs along ledges that the printed circuit boards rest upon along the +Y and -Y sides of the housing. In addition to these ledges, there are mechanical devices which, when screwed down, wedge against the top of the printed circuit boards and the housing overhang to secure the printed circuit board. These rails were assigned node numbers as follows:

- +Y bottom rail: 921
- +Y middle rail: 922
- +Y top rail: 923
- -Y bottom rail: 924
- -Y middle rail: 925
- -Y top rail: 926

These nodes will provide a means of calculating the conductance from the bottom portion of both PCB's copper thermal planes to the EPS housing. There will also be some conductance from the top layer of polyimide on both PCB's to the railing nodes via the screw attachments wedged against the top of the board, though these values would be expected to be very small.

### 2. Node Conductance Calculations

There were 8 different node calculation variations: Housing to housing; housing to PANSAT upper-equipment plate; railing to housing; PCB copper thermal-layer to railing; PCB top polyimide-layer to railing; PCB copper-layer; PCB polyimide-layer; PCB copper-layer to polyimide-layer. For the purposes of calculations, thermal nodes are physically located in the 3-dimensional center of each physical surface. A general description of each calculation variation is included below, and a listing of ITAS conductance entries is included as Appendix E.

Recall that the general formula for the calculation of conductivity between two nodes in a solid medium is:

$$K = \frac{kA}{L}$$

The general method for calculating the conductance between 2 nodes where 2 surfaces are in contact is as follows: First, calculate the conductance from 1 node to the surface interface

This is calculated using equation (5). Repeat this for the second node to surface interface, then calculate the contact conductance for the two surfaces as discussed in the background section. Once these 3 conductance's are calculated, solve the following equation for the overall conductance between the 2 nodes:

$$K_o = \frac{1}{\frac{1}{K_1} + \frac{1}{h_c} + \frac{1}{K_2}} \tag{9}$$

*a. Housing to Housing Node Calculations* [Ref. Table 1]

Conductances were calculated using equation (5) and the following thermal conductivity of aluminum:

$$k = 170 \frac{W}{m^\circ C} = 4.31 \frac{W}{in^\circ C}$$

*b. EPS Housing to PANSAT Upper Equipment Plate*

To calculate the conductance through the equipment plate, it was assumed that the equipment plate thickness was .125 in. yielding a value for L of .0625. With a total area of contact of 72 in.$^2$. Using the same thermal conductivity of k as from part a., we obtain $K_1$ = 4965 W/°C.

To calculate the conductance through the top of the EPS housing, A = 72 in$^2$ and L = .0995 in. were used, yielding $K_2$ = 3118.79 W/°C. To solve for the contact conductance, the following parameters were assumed: P = 10 psi; H = 1180 x $10^6$ n/m$^2$; $S_r$ = 7 microm. These values yielded $h_c$ = 134.136 W/°C. Now, solving for $K_o$:

$$K_o = 125 \text{ W/°C}$$

*c. Railing to Housing Conductances* [Ref. Table 2]

Although the railing nodes are mathematically distinct from the housing nodes, the physical reality is that the railings are not separate from those walls. Thus, the conductance calculations do not include contact conductances.

TABLE 1. HOUSING TO HOUSING NODE CONDUCTANCES

| FROM NODE | TO NODE | AREA ($in^2$) | LENGTH (in) | K (W/°C) |
|---|---|---|---|---|
| 901 | 905 | 0.3138 | 5.1250 | 0.2638 |
| 901 | 906 | 1.5440 | 5.2845 | 1.2592 |
| 901 | 911 | 0.3138 | 5.1250 | 0.2638 |
| 901 | 912 | 1.5440 | 5.2845 | 1.2592 |
| 902 | 903 | 0.3138 | 2.2500 | 0.6011 |
| 902 | 906 | 0.4342 | 4.7845 | 0.3911 |
| 902 | 907 | 0.3138 | 5.1250 | 0.2638 |
| 902 | 912 | 0.4342 | 4.7845 | 0.3911 |
| 903 | 904 | 0.3138 | 2.2500 | 0.6011 |
| 903 | 906 | 0.4342 | 4.7845 | 0.3911 |
| 903 | 912 | 0.4342 | 4.7845 | 0.3911 |
| 904 | 905 | 0.3138 | 2.2500 | 0.6011 |
| 904 | 906 | 0.4342 | 4.7845 | 0.3911 |
| 904 | 912 | 0.4342 | 4.7845 | 0.3911 |
| 905 | 906 | 0.4342 | 4.7845 | 0.3911 |
| 905 | 912 | 0.4342 | 4.7845 | 0.3911 |
| 908 | 906 | 0.4342 | 4.7845 | 0.3911 |
| 908 | 909 | 0.3138 | 2.2500 | 0.6011 |
| 908 | 912 | 0.4342 | 4.7845 | 0.3911 |
| 909 | 906 | 0.4342 | 4.7845 | 0.3911 |
| 909 | 910 | 0.3138 | 2.2500 | 0.6011 |
| 909 | 912 | 0.4342 | 4.7845 | 0.3911 |
| 910 | 906 | 0.4342 | 4.7845 | 0.3911 |
| 910 | 911 | 0.3138 | 2.2500 | 0.6011 |
| 910 | 912 | 0.4342 | 4.7845 | 0.3911 |
| 911 | 906 | 0.4342 | 4.7845 | 0.3911 |
| 911 | 912 | 0.4342 | 4.7845 | 0.3911 |

TABLE 2. RAILING TO HOUSING NODE CONDUCTANCES

| From Node | To Node | Area ($in^2$) | Length (in) | K (W/°C) |
|---|---|---|---|---|
| 921 | 901 | 0.0625 | 4.6000 | 0.0585 |
| 921 | 902 | 0.0625 | 4.6000 | 0.0585 |
| 921 | 903 | 0.5625 | 0.2250 | 10.7750 |
| 921 | 904 | 0.5625 | 0.2250 | 10.7750 |
| 921 | 905 | 0.5625 | 0.2250 | 10.7750 |
| 921 | 906 | 0.5625 | 0.2250 | 10.7750 |

| | | | | |
|---|---|---|---|---|
| 921 | 912 | 2.2500 | 0.2440 | 39.7438 |
| 922 | 901 | 0.1720 | 4.6000 | 0.1611 |
| 922 | 902 | 0.1720 | 4.6000 | 0.1611 |
| 922 | 903 | 1.5480 | 0.2250 | 29.6528 |
| 922 | 904 | 1.5480 | 0.2250 | 29.6528 |
| 922 | 905 | 1.5480 | 0.2250 | 29.6528 |
| 922 | 906 | 1.5480 | 0.2250 | 29.6528 |
| 923 | 901 | 0.1252 | 4.6000 | 0.1173 |
| 923 | 907 | 0.1252 | 4.6000 | 0.1173 |
| 923 | 902 | 1.1272 | 0.2250 | 21.5921 |
| 923 | 903 | 1.1272 | 0.2250 | 21.5921 |
| 923 | 904 | 1.1272 | 0.2250 | 21.5921 |
| 923 | 905 | 1.1272 | 0.2250 | 21.5921 |
| 923 | 906 | 2.2500 | 0.3470 | 27.9466 |
| 924 | 901 | 0.0625 | 4.6000 | 0.0585 |
| 924 | 907 | 0.0625 | 4.6000 | 0.0585 |
| 924 | 908 | 0.5625 | 0.2250 | 10.7750 |
| 924 | 909 | 0.5625 | 0.2250 | 10.7750 |
| 924 | 910 | 0.5625 | 0.2250 | 10.7750 |
| 924 | 911 | 0.5625 | 0.2250 | 10.7750 |
| 924 | 912 | 2.2500 | 0.2440 | 39.7438 |
| 925 | 90[illegible] | 0.1720 | 4.6000 | 0.1611 |
| 925 | 907 | 0.1720 | 4.6000 | 0.1611 |
| 925 | 908 | 1.5480 | 0.2250 | 29.6528 |
| 925 | 909 | 1.5480 | 0.2250 | 29.6528 |
| 925 | 910 | 1.5480 | 0.2250 | 29.6528 |
| 925 | 911 | 1.5480 | 0.2250 | 29.6528 |
| 926 | 901 | 0.1252 | 4.6000 | 0.1173 |
| 926 | 907 | 0.1252 | 4.6000 | 0.1173 |
| 926 | 908 | 1.1272 | 0.2250 | 21.5921 |
| 926 | 909 | 1.1272 | 0.2250 | 21.5921 |
| 926 | 910 | 1.1272 | 0.2250 | 21.5921 |
| 926 | 911 | 1.1272 | 0.2250 | 21.5921 |
| 926 | 906 | 2.2500 | 0.3470 | 27.9466 |

*d. PCB Copper to Railing Conductances*

(1) Top PCB Thermal Plane Copper to Railing. Assumptions:

P = 10 psi

$S_r$ (both) = 7 microm

$H_{al}$ = 1180 x $10^6$ n/m$^2$

$L_{cu} = .00067$ in.
$L_{rail} = .344$ in.
$k_{cu} = 9.65$ W/in°C
$k_{al} = 4.31$ W/in°C

Thus: $h_c = 2.574$ W/in$^{2}$°C

**TABLE 3. TOP PCB THERMAL PLANE COPPER TO RAILING COPPER TO RAILING CONDUCTANCES**

| FROM NODE | TO NODE | AREA (in$^2$) | $h_c$ | $K_1$(Cu) | $K_2$(A1) | $K_o$ |
|---|---|---|---|---|---|---|
| 601 | 925 | 0.3750 | 0.9652 | 5,401 | 4.6984 | 0.8007 |
| 602 | 925 | 0.6000 | 1.5444 | 8,641 | 7.5174 | 1.2811 |
| 603 | 925 | 0.6062 | 1.5604 | 8,731 | 7.5957 | 1.2945 |
| 604 | 925 | 0.9187 | 2.3648 | 13,232 | 11.5110 | 1.9620 |
| 614 | 922 | 0.1875 | 0.4826 | 2,700 | 2.3490 | 0.4003 |
| 615 | 922 | 0.2500 | 0.6435 | 3,600 | 3.1320 | 0.5338 |
| 616 | 922 | 0.3437 | 0.8848 | 4,951 | 4.3068 | 0.7340 |
| 617 | 922 | 0.6550 | 1.6859 | 9,433 | 8.2065 | 1.3986 |
| 618 | 922 | 0.8125 | 2.0913 | 11,702 | 10.1798 | 1.7351 |

(2) Bottom PCB Thermal Plane Copper to Railing. Assumptions are the same as in (1), above.

**TABLE 4. BOTTOM PCB THERMAL PLANE COPPER TO RAILING CONDUCTANCES**

| FROM NODE | TO NODE | AREA (in$^2$) | hc | $K_1$(Cu) | $K_2$(A1) | Ko |
|---|---|---|---|---|---|---|
| 1601 | 924 | 0.6250 | 1.6087 | 9,007 | 21.5500 | 1.4967 |
| 1602 | 924 | 0.7187 | 1.8500 | 10,352 | 24.7825 | 1.7123 |
| 1603 | 924 | 0.5625 | 1.4478 | 8,101 | 19.3950 | 1.3470 |
| 1604 | 924 | 0.3437 | 0.8848 | 4,951 | 11.8525 | 0.8232 |
| 1609 | 921 | 0.6250 | 1.6087 | 9,001 | 21.5500 | 1.4967 |
| 1610 | 921 | 0.7187 | 1.8500 | 10,352 | 24.7825 | 1.7213 |
| 1611 | 921 | 0.5625 | 1.4478 | 8,101 | 19.3950 | 1.3470 |
| 1612 | 921 | 0.3437 | 0.8848 | 4,951 | 11.8525 | 0.8232 |

*e. PCB Polyimide to Railing Conductances*

(1) Top PCB. Assumptions:
P = 10 psi
$S_r$ (both) = 7 microm

$H_{poly} = 1537 \times 10^6$ N/m$^2$
$L_{rail} = .344$ in.
$L_{poly} = .00966$ in.
$k_{poly} = .2$ W/m°C

Thus, $h_c = .004378$ W/in$^{2\circ}$C

**TABLE 5. TOP PCB POLYIMIDE LAYER TO RAILING CONDUCTANCES**

| FROM NODE | TO NODE | AREA(in$^2$) | $h_c$ | $K_1$(Poly) | $K_2$(Al) | $K_0$ |
|---|---|---|---|---|---|---|
| 101 | 926 | 0.3750 | 0.0016 | 0.1940 | 6.4520 | 0.0016 |
| 102 | 926 | 0.6000 | 0.0026 | 0.3100 | 10.3233 | 0.0026 |
| 103 | 926 | 0.6062 | 0.0026 | 0.3130 | 10.4308 | 0.0026 |
| 104 | 926 | 0.9187 | 0.0040 | 0.4750 | 15.8076 | 0.0039 |
| 114 | 923 | 0.1875 | 0.0008 | 0.0970 | 3.2260 | 0.0008 |
| 115 | 923 | 0.2500 | 0.0011 | 0.1290 | 4.3013 | 0.0010 |
| 116 | 923 | 0.3437 | 0.0015 | 0.1770 | 5.9144 | 0.0014 |
| 117 | 923 | 0.6550 | 0.0028 | 0.3390 | 11.2696 | 0.0028 |
| 118 | 923 | 0.8125 | 0.0035 | 0.4200 | 13.9775 | 0.0035 |

(2) Bottom PCB. Assumptions are the same as above.

**TABLE 6. BOTTOM PCB POLYIMIDE LAYER TO RAILING CONDUCTANCES**

| FROM NODE | TO NODE | AREA (in$^2$) | $h_c$ | $K_1$(Poly) | $K_2$(Al) | $K_0$ |
|---|---|---|---|---|---|---|
| 1101 | 925 | 0.6250 | 0.0027 | 0.3234 | 7.8306 | 0.0027 |
| 1102 | 925 | 0.7187 | 0.0031 | 0.3720 | 9.0052 | 0.0031 |
| 1103 | 925 | 0.5625 | 0.0024 | 0.2911 | 7.0476 | 0.0024 |
| 1104 | 925 | 0.3437 | 0.0015 | 0.1779 | 4.3068 | 0.0014 |
| 1109 | 922 | 0.6285 | 0.0027 | 0.3234 | 7.8306 | 0.0027 |
| 1110 | 922 | 0.7187 | 0.0031 | 0.3720 | 9.0052 | 0.0031 |
| 1111 | 922 | 0.5625 | 0.0024 | 0.2911 | 7.0476 | 0.0024 |
| 1112 | 922 | 0.3437 | 0.0015 | 0.1779 | 4.3068 | 0.0014 |

*f. PCB Copper-layer Conductances*

(1) Top PCB.

TABLE 7. TOP PCB COPPER-LAYER CONDUCTANCES

| FROM NODE | TO NODE | AREA ($in^2$) | LENGTH (in) | K (W/°C) |
|---|---|---|---|---|
| 601 | 602 | 0.0033 | 1.9500 | 0.0165 |
| 601 | 605 | 0.0020 | 2.6250 | 0.0073 |
| 602 | 603 | 0.0033 | 2.4125 | 0.0134 |
| 602 | 606 | 0.0033 | 2.6250 | 0.0118 |
| 603 | 604 | 0.0033 | 2.5500 | 0.0126 |
| 603 | 607 | 0.0032 | 2.6250 | 0.0119 |
| 604 | 608 | 0.0035 | 2.6250 | 0.0131 |
| 605 | 606 | 0.0036 | 1.9500 | 0.0182 |
| 605 | 609 | 0.0010 | 2.0312 | 0.0030 |
| 605 | 610 | 0.0010 | 2.0312 | 0.0030 |
| 606 | 607 | 0.0036 | 2.4125 | 0.0148 |
| 606 | 610 | 0.0003 | 2.0312 | 0.0015 |
| 606 | 611 | 0.0018 | 2.0312 | 0.0087 |
| 606 | 612 | 0.0010 | 2.0312 | 0.0049 |
| 607 | 608 | 0.0036 | 2.5500 | 0.0139 |
| 607 | 612 | 0.0024 | 2.0312 | 0.0117 |
| 607 | 613 | 0.0007 | 2.0312 | 0.0036 |
| 608 | 613 | 0.0035 | 2.0312 | 0.0170 |
| 609 | 610 | 0.0017 | 0.8750 | 0.0194 |
| 609 | 614 | 0.0010 | 1.3750 | 0.0045 |
| 610 | 611 | 0.0017 | 1.1875 | 0.0143 |
| 610 | 615 | 0.0013 | 1.3750 | 0.0094 |
| 611 | 612 | 0.0017 | 2.0000 | 0.0085 |
| 611 | 616 | 0.0018 | 1.3750 | 0.0129 |
| 612 | 613 | 0.0017 | 2.9375 | 0.0057 |
| 612 | 617 | 0.0035 | 2.9375 | 0.0115 |
| 613 | 618 | 0.0043 | 1.3750 | 0.0305 |
| 614 | 615 | 0.0019 | 0.8750 | 0.0212 |
| 615 | 616 | 0.0019 | 1.1875 | 0.0182 |
| 616 | 617 | 0.0019 | 2.0000 | 0.0108 |
| 617 | 618 | 0.0019 | 1.3750 | 0.0157 |

These conductances were utilized for all three copper layers of the top printed circuit board.

(2) Bottom PCB.

**TABLE 8. BOTTOM PCB COPPER-LAYER CONDUCTANCES**

| FROM NODE | TO NODE | AREA (in$^2$) | LENGTH (in) | K (W/°C) |
|---|---|---|---|---|
| 1601 | 1602 | 0.0033 | 2.3750 | 0.0136 |
| 1601 | 1604 | 0.0046 | 2.6875 | 0.0168 |
| 1602 | 1603 | 0.0033 | 2.2500 | 0.0143 |
| 1602 | 1605 | 0.0016 | 2.6875 | 0.0060 |
| 1603 | 1606 | 0.0043 | 2.6875 | 0.0156 |
| 1604 | 1605 | 0.0038 | 2.3750 | 0.0156 |
| 1604 | 1607 | 0.0046 | 2.5625 | 0.0176 |
| 1605 | 1606 | 0.0038 | 2.2500 | 0.0165 |
| 1605 | 1608 | 0.0016 | 2.5625 | 0.0063 |
| 1606 | 1609 | 0.0043 | 2.5625 | 0.0164 |
| 1607 | 1608 | 0.0030 | 2.3750 | 0.0122 |
| 1607 | 1610 | 0.0046 | 1.8125 | 0.0249 |
| 1608 | 1609 | 0.0030 | 2.2500 | 0.0129 |
| 1608 | 1611 | 0.0016 | 1.8125 | 0.0089 |
| 1609 | 1612 | 0.0043 | 1.8125 | 0.0231 |
| 1610 | 1611 | 0.0018 | 2.3750 | 0.0074 |
| 1611 | 1612 | 0.0018 | 2.2500 | 0.0079 |

These conductances were utilized for all three copper-layers of the bottom printed circuit board.

*g. PCB Polyimide-layer Conductances*

(1) Top PCB.

**TABLE 9. TOP PCB POLYIMIDE-LAYER CONDUCTANCES**

| FROM NODE | TO NODE | AREA (in$^2$) | LENGTH (in) | K (W/°C) |
|---|---|---|---|---|
| 501 | 502 | 0.0483 | 1.9500 | 0.00012 |
| 501 | 505 | 0.0289 | 2.6250 | 0.00005 |
| 502 | 503 | 0.0483 | 2.4125 | 0.00010 |
| 502 | 506 | 0.0463 | 2.6250 | 0.00008 |
| 503 | 504 | 0.0483 | 2.5500 | 0.00009 |
| 503 | 507 | 0.0468 | 2.6250 | 0.00009 |
| 504 | 508 | 0.0517 | 2.6250 | 0.00009 |
| 505 | 506 | 0.0531 | 1.9500 | 0.00013 |
| 505 | 509 | 0.0145 | 2.0312 | 0.00003 |
| 505 | 510 | 0.0145 | 2.0312 | 0.00003 |

| | | | | |
|---|---|---|---|---|
| 506 | 507 | 0.0531 | 2.4125 | 0.00011 |
| 506 | 510 | 0.0048 | 2.0312 | 0.00001 |
| 506 | 511 | 0.0265 | 2.0312 | 0.00006 |
| 506 | 512 | 0.0149 | 2.0312 | 0.00003 |
| 507 | 508 | 0.0531 | 2.5500 | 0.00010 |
| 507 | 512 | 0.0357 | 2.0312 | 0.00008 |
| 507 | 513 | 0.0111 | 2.0312 | 0.00002 |
| 508 | 513 | 0.0517 | 2.0312 | 0.00012 |
| 509 | 510 | 0.0253 | 0.8750 | 0.00014 |
| 509 | 514 | 0.0144 | 1.3750 | 0.00005 |
| 510 | 511 | 0.0253 | 1.1875 | 0.00010 |
| 510 | 515 | 0.0193 | 1.3750 | 0.00007 |
| 511 | 512 | 0.0253 | 2.0000 | 0.00006 |
| 511 | 516 | 0.0265 | 1.3750 | 0.00009 |
| 512 | 513 | 0.0253 | 2.9375 | 0.00004 |
| 512 | 517 | 0.0507 | 2.9375 | 0.00008 |
| 513 | 518 | 0.0628 | 1.3750 | 0.00023 |
| 514 | 515 | 0.0277 | 0.8750 | 0.00016 |
| 515 | 516 | 0.0277 | 1.1875 | 0.00011 |
| 516 | 517 | 0.0277 | 2.0000 | 0.00007 |
| 517 | 518 | 0.0277 | 1.3750 | 0.00010 |

These conductances were utilized for all three polyimide-layers of the top printed circuit board.

(2) Bottom PCB.

**TABLE 10. BOTTOM PCB POLYIMIDE-LAYER CONDUCTANCES**

| FROM NODE | TO NODE | AREA (in$^2$) | LENGTH (in) | K (W/°C) |
|---|---|---|---|---|
| 1101 | 1102 | 0.0483 | 2.3750 | 0.00010 |
| 1101 | 1104 | 0.0676 | 2.6875 | 0.00012 |
| 1102 | 1103 | 0.0483 | 2.2500 | 0.00010 |
| 1102 | 1105 | 0.0241 | 2.6875 | 0.00004 |
| 1103 | 1106 | 0.0628 | 2.6875 | 0.00011 |
| 1104 | 1105 | 0.0676 | 2.5625 | 0.00013 |
| 1104 | 1107 | 0.0555 | 2.3750 | 0.00011 |
| 1105 | 1106 | 0.0555 | 2.2500 | 0.00012 |
| 1105 | 1108 | 0.0241 | 2.5625 | 0.00004 |

| | | | | |
|---|---|---|---|---|
| 1106 | 1109 | 0.0628 | 2.5625 | 0.00012 |
| 1107 | 1108 | 0.0676 | 1.8125 | 0.00018 |
| 1107 | 1110 | 0.0434 | 2.3750 | 0.00009 |
| 1108 | 1109 | 0.0434 | 2.2500 | 0.00009 |
| 1108 | 1111 | 0.0241 | 1.8125 | 0.00006 |
| 1109 | 1112 | 0.0628 | 1.8125 | 0.00017 |
| 1110 | 1111 | 0.0265 | 2.3750 | 0.00005 |
| 1111 | 1112 | 0.0265 | 2.2500 | 0.00005 |

These conductance's were utilized for all three polyimide-layers of the bottom printed circuit board.

*h. PCB Copper-layer to Polyimide-layer Conductances*

(1) Top PCB. Assumptions are as follows:

$P = 10$ psi
$H_{poly} = 1537 \times 10^6$ N/m$^2$
$S_r = 7$ microm.
$L_{cu} = .00067$ in.
$L_{poly} = .00966$ in.
$k_{cu} = 4.31$ W/in°C
$k_{poly} = .2$ W/in°C

Yields: $h^c = .0034$ W/in$^{2o}$C

These conductances are listed in Table 11 and were utilized for all copper-layer to polyimide-layer conductance relationships for the top PCB.

**TABLE 11. TOP PCB COPPER-LAYER TO POLYIMIDE-LAYER CONDUCTANCES**

| FROM NODE | TO NODE | AREA(in$^2$) | $h_c$ | $K_1$(Cu) | $K_2$(A1) | $K_o$ |
|---|---|---|---|---|---|---|
| 601 | 501 | 3.7500 | 0.0127 | 54,011 | 1.9400 | 0.0126 |
| 602 | 502 | 6.0000 | 0.0204 | 86,417 | 3.1000 | 0.0202 |
| 603 | 503 | 6.0620 | 0.0206 | 87,310 | 3.1370 | 0.0204 |
| 604 | 504 | 6.6780 | 0.0227 | 96,312 | 3.4610 | 0.0225 |
| 605 | 505 | 4.1250 | 0.0140 | 59,412 | 2.1350 | 0.0139 |
| 606 | 506 | 6.6000 | 0.0224 | 95,059 | 3.4160 | 0.0222 |
| 607 | 507 | 6.6680 | 0.0226 | 96,039 | 3.4510 | 0.0225 |
| 608 | 508 | 7.3560 | 0.0250 | 105,948 | 3.8070 | 0.0071 |
| 609 | 509 | 0.9840 | 0.0033 | 14,172 | 0.5090 | 0.0033 |
| 610 | 510 | 1.3125 | 0.0044 | 18,903 | 0.6790 | 0.0044 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 611 | 511 | 1.8040 | 0.0061 | 25,982 | 0.9330 | 0.0060 |
| 612 | 512 | 3.4780 | 0.0118 | 50,093 | 1.8000 | 0.0117 |
| 613 | 513 | 4.2650 | 0.0145 | 61,428 | 2.2070 | 0.0144 |
| 614 | 514 | 1.0780 | 0.0036 | 15,526 | 0.5570 | 0.0036 |
| 615 | 515 | 1.4375 | 0.0048 | 20,704 | 0.7440 | 0.0048 |
| 616 | 516 | 1.9760 | 0.0067 | 28,460 | 1.0220 | 0.0066 |
| 617 | 517 | 3.8090 | 0.0129 | 54,860 | 1.9710 | 0.0128 |
| 618 | 518 | 1.8040 | 0.0061 | 25,982 | 0.9330 | 0.0060 |

(2) Bottom PCB. Assumptions made were the same as above in (1).

**TABLE 12. BOTTOM PCB COPPER-LAYER TO POLYIMIDE-LAYER CONDUCTANCES**

| From node | To Node | Area (in$^2$) | $h_c$ | $K_1$(Cu) | $K_2$(A1) | $K_0$ |
|---|---|---|---|---|---|---|
| 1601 | 1501 | 8.7500 | 0.0297 | 126,026 | 4.5200 | 0.0295 |
| 1602 | 1502 | 3.1250 | 0.0106 | 45,009 | 1.6174 | 0.0105 |
| 1603 | 1503 | 8.1250 | 0.0276 | 117,024 | 4.2054 | 0.0274 |
| 1604 | 1504 | 10.0625 | 0.0342 | 144,930 | 5.2083 | 0.0339 |
| 1605 | 1505 | 3.5937 | 0.0122 | 51,760 | 1.8601 | 0.0121 |
| 1606 | 1506 | 9.3437 | 0.0317 | 134,577 | 4.8363 | 0.0315 |
| 1607 | 1507 | 7.8750 | 0.0267 | 113,423 | 4.0760 | 0.0266 |
| 1608 | 1508 | 2.8125 | 0.0095 | 40,508 | 1.4559 | 0.0095 |
| 1609 | 1509 | 7.3125 | 0.0248 | 105,321 | 3.7849 | 0.0247 |
| 1610 | 1510 | 4.8125 | 0.0163 | 69,314 | 2.4909 | 0.0162 |
| 1611 | 1511 | 1.7187 | 0.0058 | 24,755 | 0.8896 | 0.0058 |
| 1612 | 1512 | 4.4687 | 0.0151 | 64,363 | 2.3130 | 0.0150 |

These conductances were utilized for all copper-layer to polyimide-layer conductance relationships for the bottom printed circuit board.

## D. THERMAL MODEL PARAMETERS

### 1. Boundary Conditions

The boundary conditions for this steady-state thermal model involved both the temperature of the PANSAT upper-equipment plate and the amount of heat dissipated by printed circuit board electronic components. Boundary conditions were established for worst-case cold and worst-case hot conditions. For both cases, a starting temperature of 20°C was assigned to each surface node in the model.

#### *a. Cold-Case*

For the cold-case, the thermal node for the upper equipment plate, node number -913, was set equal to a constant 0°C. For power dissipation in the printed circuit boards, it was assumed that any component with less than a 100% duty cycle would be off. Further, the amount of heat dissipated would be for the eclipse period of the orbit.

#### *b. Hot-Case*

For the hot-case, the thermal node for the upper equipment plate, node number -913, was set equal to a constant 40°C. For power dissipation in the printed circuit boards, it was assumed that every component would be on, with the amount of heat dissipated being that for the sunlit portion of the orbit.

### 2. ITAS Inputs

#### *a. Cold-Case*

ITAS cold-case data entries and inputs are given in Appendix F.

#### *b. Hot-Case*

ITAS hot-case data entries and inputs are given in Appendix G. Note that the hot-case data entry Appendix G contains only the changes to the cold-case data entry Appendix F.

# III. RESULTS AND ANALYSIS

## A. ITAS OUTPUT

Actual running time for ITAS modeling for both the hot and cold cases was less than 2 minutes. By examining Appendices F and G it can be seen that ITAS first calculates the view-factor for each surface, then the radiated energy intercepted by that surface. Finally, the heat conduction for the model is calculated. Cold-case outputs can be found at the end of Appendix H. and hot-case outputs are located at the end of Appendix I.

## B. ANALYSIS

### 1. Cold-Case

Examination of the ITAS calculated steady-state temperature for surfaces in the cold-case shows that temperatures range from a low of .12°C at the top of the EPS housing to a high of 20°C in the PCB's. This would seem to be a valid result since the largest possible heat transfer for this model should occur between nodes 906 and -913, the top of the EPS housing and the PANSAT upper equipment plate, respectively. With a constant temperature of 0°C for node -913, this node will act as a heat sink drawing heat away from the EPS housing due to the higher starting temperature of 20°C for the EPS surfaces and the heat being dissipated in the PCB's which will seek a conductive path to the heat sink. Since the conductive paths will allow only a finite amount of heat to be transferred in any given time, the relative temperatures of the surfaces illustrates a decreasing trend as a function of conductive path nearness to the upper-equipment plate. A complete listing of steady-state temperatures for each thermal node is given at the end of Appendix H, with a graphical representation of the temperature gradient utilizing selected nodes given in Figure 3. For both the cold-case and hot-case temperature gradient graphs, the paths selected represent worst-case paths for both the top and bottom printed circuit boards. This means that for the cold-case, starting at 0°C for node -913 to .12°C for node 906, the thermal path for the top and bottom printed circuit boards then diverge to different nodes with the top printed circuit board

thermal path proceeding to node 925 and the bottom printed circuit board thermal path proceeding to node 924. For the hot-case, the procedure is similar.

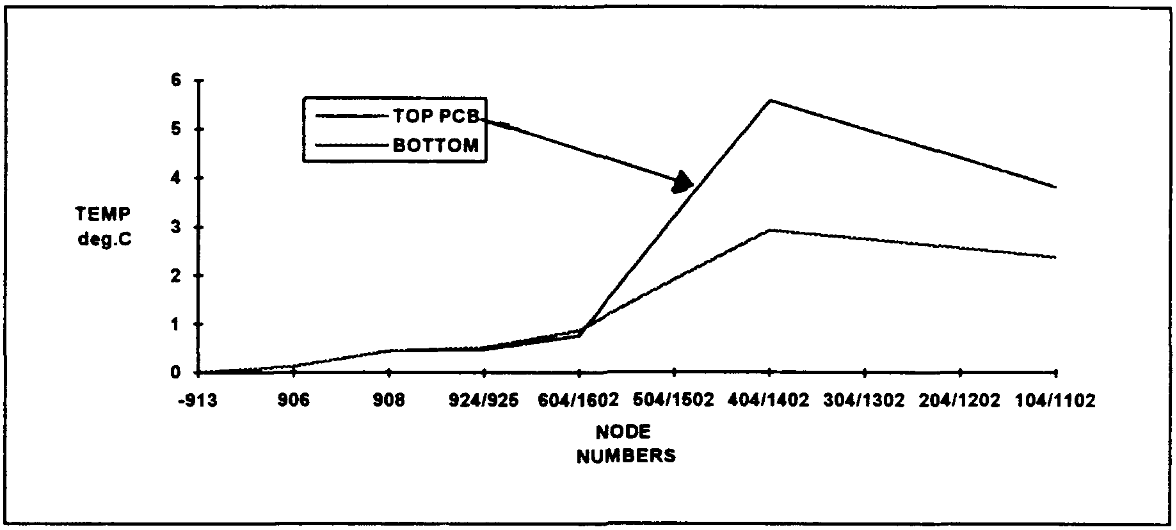



**Figure 3. Cold-Case Temperature Gradient for Selected Nodes**

## 2. Hot-Case

Examination of the ITAS calculated steady-state temperatures for surfaces in the hot case shows that temperatures range from a low of 20°C within the PCB's to a high of 39.91°C for the top of the EPS housing at node 906, the interface with the upper-equipment plate. The explanation for these results is similar to that described above for the cold-case, except that in the hot-case the upper-equipment plate is acting as a heat source for the EPS housing and PCB's. A complete listing of steady-state temperatures for each thermal node is given at the end of Appendix I, with a graphical representation of the temperature gradient utilizing selected nodes given in Figure 4.

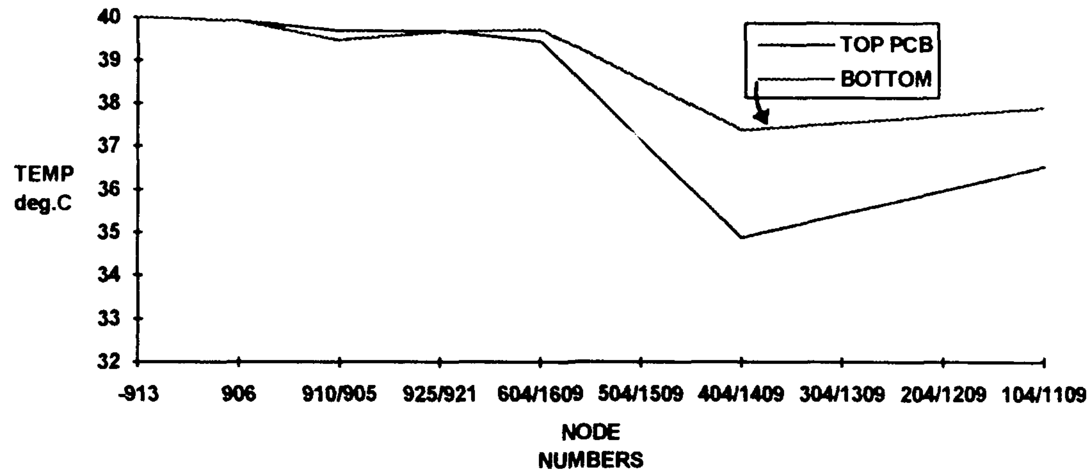



**Figure 4. Hot-Case Temperature Gradient for Selected Nodes**

## C. CONCLUSIONS

It seems clear, given the results of this thermal model, that if only inward-viewing geometry and conductance relationships were taken into consideration that the thermal profile of the EPS housing and its associated electronic components on the PCB's would be at the mercy of the upper-equipment plate temperature. So large is the conductive path between the EPS housing and the upper equipment plate in comparison with all other conductive relationships, and given that the upper-equipment plate temperature is determined by the overall PANSAT temperature, it is critical that the normal on-orbit operating temperature limits of PANSAT be determined to within 10° of accuracy to preclude the possibility of electronic component failure. A reasonable first-order estimate of spacecraft temperature extremes can be obtained by the process given in Reference 3, page 425. If it proves to be too difficult to determine the temperature extremes to within the desired accuracy range, additional measures might be necessary to ensure EPS thermal integrity. Such measures might include the application of grease to the EPS-housing / upper-equipment plate interface, EPS specific heaters (mounted to the upper-equipment plate or the EPS housing itself),

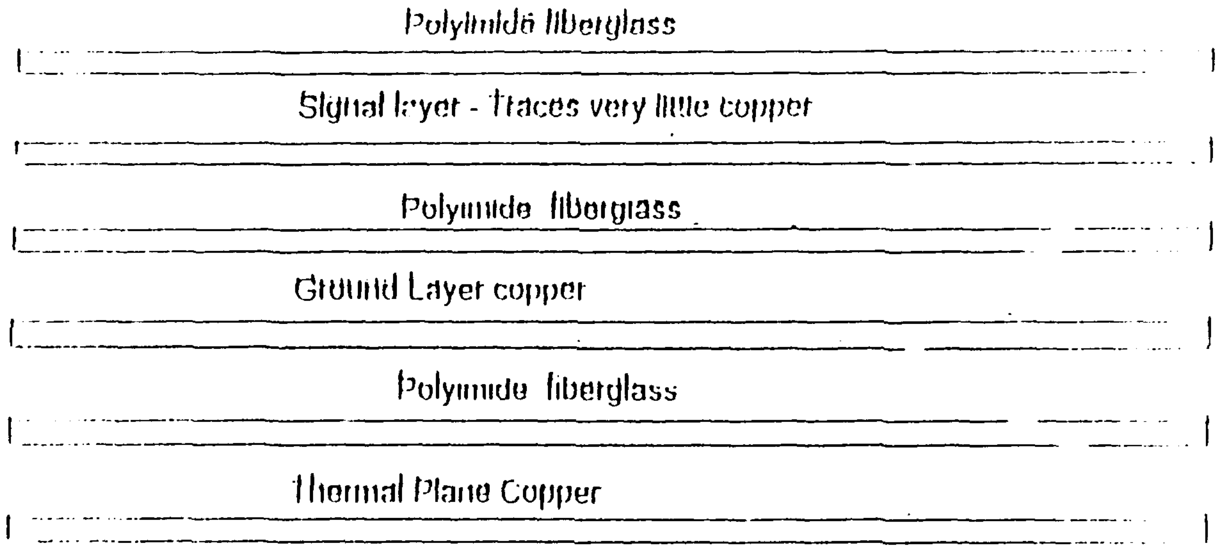
additional insulation for the housing, or an increase in the active control of the overall PANSAT thermal environment.

## D. RECOMMENDATIONS

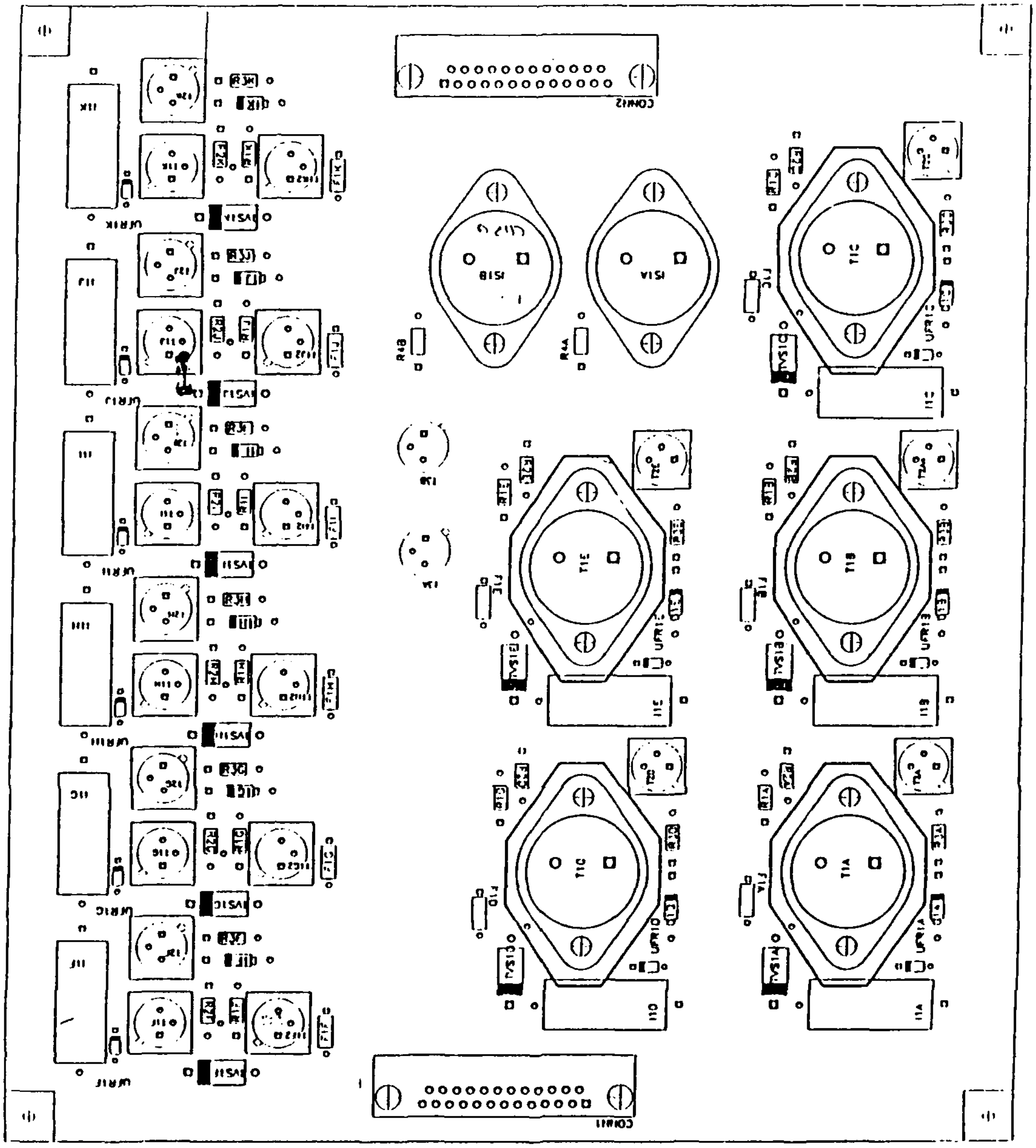
It is recommended that this thermal model be incorporated into the larger overall thermal model of the PANSAT. This could be accomplished most efficiently by utilizing this model as one of many modules with each module representing the major subsystems and components of the PANSAT. Further, it is desirable that a thermal test of the EPS system hardware be conducted in a vacuum chamber to test the closeness of the software modeling results to a "real-world" test of a physical system.

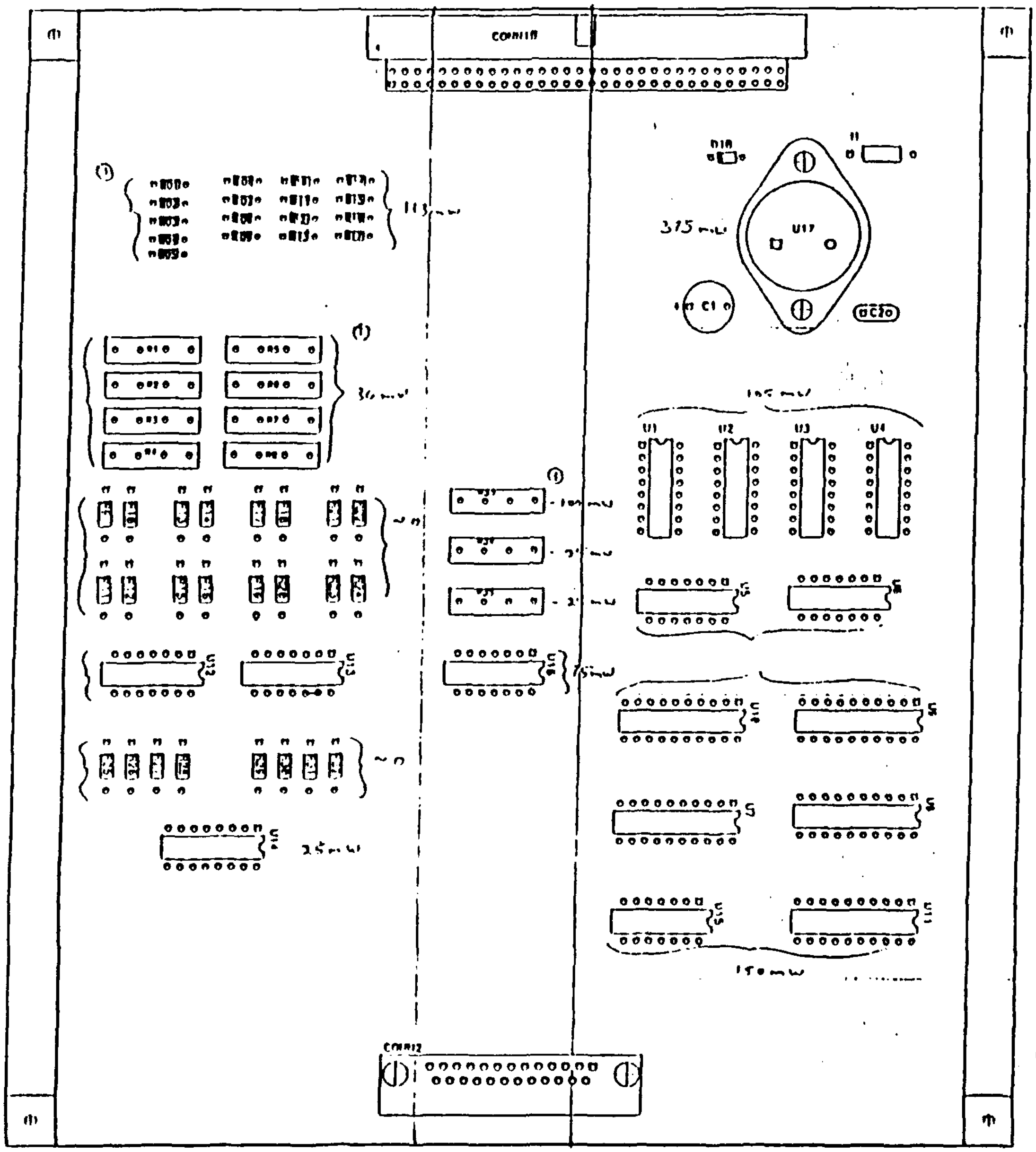
# APPENDIX A

## PCB Layer-Layer



# PRINTED CIRCUIT BOARD LAYOUTS






(1) Power Dissipation occurs only in Supply Portion of Board

EPS Switch Board

| Component | Designator | Subcircuit | Duty cycle | Power Dissipation, Bus = 15V (Sunlit) | Power Dissipation, Bus = 12V (Eclipse) | X-Coord | Y-Coord |
|---|---|---|---|---|---|---|---|
| Inductor | I1A | DCSA Power Switch | 100 | 0.039 | 0.061 | 2.200 | 8.900 |
| Transient Voltage Suppressor | TVS1A | " | ~0 | | | 2.925 | 8.637 |
| Ultra Fast Recovery Diode | UFR1A | " | ~0 | | | 1.825 | 8.600 |
| 12v Zener Bi-Directional | D1A | " | ~0 | | | 1.650 | 8.125 |
| PMOSFET Gate Bias Resister | R1A | " | 100 | 0.002 | 0.001 | 3.025 | 7.250 |
| PMOSFET Gate Bias Resister | R2A | " | 100 | 0.000 | 0.000 | 2.850 | 7.075 |
| NMOSFET Gate Protection Resister | R3A | " | 100 | 0.003 | 0.003 | 1.650 | 7.575 |
| PMOSFET | T1A | " | 100 | 0.006 | 0.009 | 2.375 | 7.850 |
| NMOSFET | T2A | " | 100 | 0.000 | 0.000 | 1.775 | 7.000 |
| Pico Fuse | F1A | " | | | | 3.150 | 8.075 |
| | | | | | | | |
| Inductor | I1B | DCSB Power Switch | 100 | 0.039 | 0.061 | 2.200 | 6.475 |
| Transient Voltage Suppressor | TVS1B | " | ~0 | | | 2.925 | 6.212 |
| Ultra Fast Recovery Diode | UFR1B | " | ~0 | | | 1.825 | 6.175 |
| 12v Zener Bi-Directional | D1B | " | ~0 | | | 1.650 | 5.700 |
| PMOSFET Gate Bias Resister | R1B | " | 100 | 0.002 | 0.001 | 3.025 | 4.825 |
| PMOSFET Gate Bias Resister | R2B | " | 100 | 0.000 | 0.000 | 2.850 | 4.650 |
| NMOSFET Gate Protection Resister | R3B | " | 100 | 0.003 | 0.003 | 1.650 | 5.150 |
| PMOSFET | T1B | " | 100 | 0.006 | 0.009 | 2.375 | 5.425 |
| NMOSFET | T2B | " | 100 | 0.000 | 0.000 | 1.775 | 4.575 |
| Pico Fuse | F1B | " | | | | 3.150 | 5.650 |
| | | | | | | | |
| Inductor | I1C | RF Power Switch - *Rx only* | 70 | 0.010 | 0.015 | 2.200 | 4.050 |
| Transient Voltage Suppressor | TVS1C | " | ~0 | | | 2.925 | 3.787 |
| Ultra Fast Recovery Diode | UFR1C | " | ~0 | | | 1.825 | 3.750 |
| 12v Zener Bi-Directional | D1C | " | ~0 | | | 1.650 | 3.275 |
| PMOSFET Gate Bias Resister | R1C | " | 100 | 0.002 | 0.001 | 3.025 | 2.400 |
| PMOSFET Gate Bias Resister | R2C | " | 100 | 0.000 | 0.000 | 2.850 | 2.225 |
| NMOSFET Gate Protection Resister | R3C | " | 70 | 0.003 | 0.003 | 1.650 | 2.725 |
| PMOSFET | T1C | " | 70 | 0.006 | 0.009 | 2.375 | 3.000 |
| NMOSFET | T2C | " | 70 | 0.000 | 0.000 | 1.775 | 2.150 |
| Pico Fuse | F1C | " | | | | 3.150 | 3.225 |
| | | | | | | | |
| Inductor | I1C | RF Power Switch - *Rx and Tx* | 30 | 0.088 | 0.138 | | |
| Transient Voltage Suppressor | TVS1C | " | ~0 | | | | |
| Ultra Fast Recovery Diode | UFR1C | " | ~0 | | | | |
| 12v Zener Bi-Directional | D1C | " | ~0 | | | | |
| PMOSFET Gate Bias Resister | R1C | " | 30 | 0.002 | 0.001 | | |

EPS Switch Board

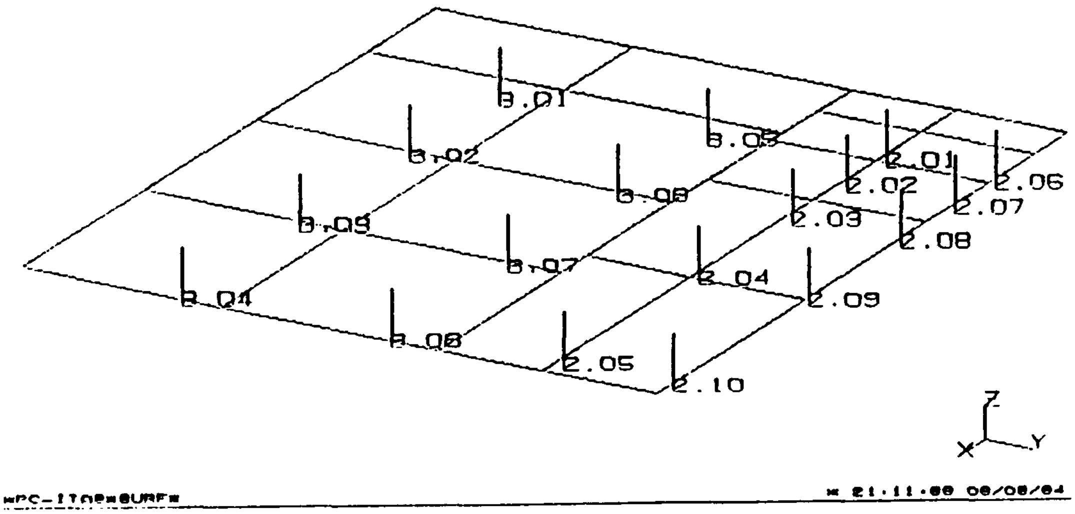
| Component | Designator | Subcircuit | Duty cycle | Power Dissipation, Bus = 15V (Sunlit) | Power Dissipation, Bus = 12V (Eclipse) | X-Coord | Y-Coord |
|---|---|---|---|---|---|---|---|
| PMOSFET Gate Bias Resister | R2C | " | 30 | 0.000 | 0.000 | | |
| NMOSFET Gate Protection Resister | R3C | " | 30 | 0.003 | 0.003 | | |
| PMOSFET | T1C | " | 30 | 0.014 | 0.021 | | |
| NMOSFET | T2C | " | 30 | 0.000 | 0.000 | | |
| Pico Fuse | F1C | " | | | | | |
| | | | | | | | |
| | | | | | | | |
| Inductor | I1D | CHARG Battery A Power Switch | 60 | 0.012 | N/A | 4.300 | 8.900 |
| Transient Voltage Suppressor | TVS1D | " | ~0 | | " | 5.025 | 8.637 |
| Ultra Fast Recovery Diode | UFR1D | " | ~0 | | " | 3.925 | 8.600 |
| 12v Zener Bi-Directional | D1D | " | ~0 | | " | 3.750 | 8.125 |
| PMOSFET Gate Bias Resister | R1D | " | 60 | 0.002 | " | 5.125 | 7.250 |
| PMOSFET Gate Bias Resister | R2D | " | 60 | 0.000 | " | 4.950 | 7.075 |
| NMOSFET Gate Protection Resister | R3D | " | 60 | 0.003 | 0.003 | 3.750 | 7.575 |
| PMOSFET | T1D | " | 60 | 0.008 | " | 4.475 | 7.850 |
| NMOSFET | T2D | " | 60 | 0.000 | " | 3.875 | 7.000 |
| Pico Fuse | F1D | " | | | " | 5.250 | 8.175 |
| | | | | | | | |
| Inductor | I1E | CHARG Battery B Power Switch | 60 | 0.050 | N/A | 4.300 | 6.475 |
| Transient Voltage Suppressor | TVS1E | " | ~0 | | " | 5.025 | 6.212 |
| Ultra Fast Recovery Diode | UFR1E | " | ~0 | | " | 3.925 | 6.175 |
| 12v Zener Bi-Directional | D1E | " | ~0 | | " | 3.750 | 5.700 |
| PMOSFET Gate Bias Resister | R1E | " | 60 | 0.002 | " | 5.125 | 4.825 |
| PMOSFET Gate Bias Resister | R2E | " | 60 | 0.000 | " | 4.950 | 4.650 |
| NMOSFET Gate Protection Resister | R3E | " | 60 | 0.003 | 0.003 | 3.750 | 5.150 |
| PMOSFET | T1E | " | 60 | 0.008 | " | 4.475 | 5.425 |
| NMOSFET | T2E | " | 60 | 0.000 | " | 3.875 | 4.575 |
| Pico Fuse | F1E | " | | | " | 5.250 | 5.650 |
| | | | | | | | |
| Inductor | I1F | MUX A | 30 | 0.006 | 0.009 | 8.400 | 8.875 |
| Transient Voltage Suppressor | TVS1F | " | ~0 | | | 7.297 | 9.450 |
| Ultra Fast Recovery Diode | UFR1F | " | ~0 | | | 8.125 | 9.225 |
| 12v Zener Bi-Directional | D1F | " | ~0 | | | 7.175 | 8.550 |
| PMOSFET Gate Bias Resister | R1F | " | 30 | 0.002 | 0.001 | 7.175 | 8.950 |
| PMOSFET Gate Bias Resister | R2F | " | 30 | 0.000 | 0.000 | 7.400 | 8.950 |
| NMOSFET Gate Protection Resister | R3F | " | 30 | 0.003 | 0.003 | 7.225 | 8.375 |
| PMOSFET | T1F | " | 30 | 0.003 | 0.004 | 7.775 | 9.050 |
| PMOSFET | T1F2 | " | 30 | 0.003 | 0.004 | 6.850 | 9.050 |
| NMOSFET | T2F | " | 30 | 0.000 | 0.000 | 7.775 | 8.450 |
| Pico Fuse | F1F | " | 100 | | | 6.475 | 9.125 |

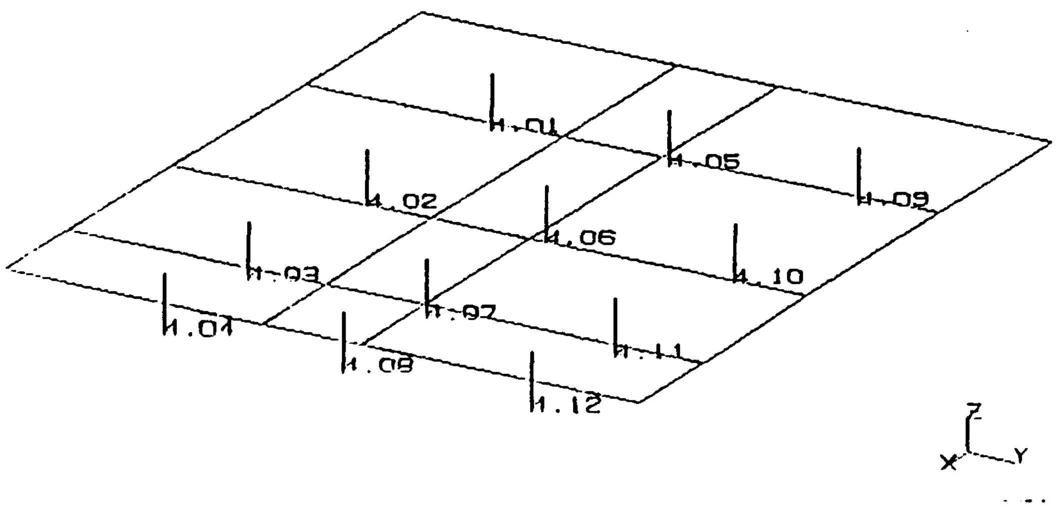
EPS Switch Board

| Component | Designator | Subcircuit | Duty cycle | Power Dissipation, Bus = 15V (Sunlit) | Power Dissipation, Bus = 12V (Eclipse) | X-Coord | Y-Coord |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Inductor | I1G | MUX B | 30 | 0.006 | 0.009 | 8.400 | 7.525 |
| Transient Voltage Suppressor | TVS1G | " | ~0 | | | 7.297 | 8.100 |
| Ultra Fast Recovery Diode | UFR1G | " | ~0 | | | 8.125 | 7.875 |
| 12v Zener Bi-Directional | D1G | " | ~0 | | | 7.175 | 7.200 |
| PMOSFET Gate Bias Resister | R1G | " | 30 | 0.002 | 0.001 | 7.175 | 7.600 |
| PMOSFET Gate Bias Resister | R2G | " | 30 | 0.000 | 0.000 | 7.400 | 7.600 |
| NMOSFET Gate Protection Resister | R3G | " | 30 | 0.003 | 0.003 | 7.225 | 7.025 |
| PMOSFET | T1G | " | 30 | 0.003 | 0.004 | 7.775 | 7.700 |
| PMOSFET | T1G2 | " | 30 | 0.003 | 0.004 | 6.850 | 7.700 |
| NMOSFET | T2G | " | 30 | 0.000 | 0.000 | 7.775 | 7.100 |
| Pico Fuse | F1G | " | 100 | | | 6.475 | 7.775 |
| | | | | | | | |
| Inductor | I1H | MASS A | 30 | 0.001 | 0.002 | 8.400 | 6.175 |
| Transient Voltage Suppressor | TVS1H | " | ~0 | | | 7.297 | 6.750 |
| Ultra Fast Recovery Diode | UFR1H | " | ~0 | | | 8.125 | 6.525 |
| 12v Zener Bi-Directional | D1H | " | ~0 | | | 7.175 | 5.850 |
| PMOSFET Gate Bias Resister | R1H | " | 30 | 0.002 | 0.001 | 7.175 | 6.250 |
| PMOSFET Gate Bias Resister | R2H | " | 30 | 0.000 | 0.000 | 7.400 | 6.250 |
| NMOSFET Gate Protection Resister | R3H | " | 30 | 0.003 | 0.003 | 7.225 | 5.675 |
| PMOSFET | T1H | " | 30 | 0.001 | 0.001 | 7.775 | 6.350 |
| PMOSFET | T1H2 | " | 30 | 0.001 | 0.001 | 6.850 | 6.350 |
| NMOSFET | T2H | " | 30 | 0.000 | 0.000 | 7.775 | 5.750 |
| Pico Fuse | F1H | " | 100 | | | 6.475 | 6.425 |
| | | | | | | | |
| Inductor | I1I | MASS B | 30 | 0.001 | 0.002 | 8.400 | 4.825 |
| Transient Voltage Suppressor | TVS1I | " | ~0 | | | 7.297 | 5.400 |
| Ultra Fast Recovery Diode | UFR1I | " | ~0 | | | 8.125 | 5.175 |
| 12v Zener Bi-Directional | D1I | " | ~0 | | | 7.175 | 4.500 |
| PMOSFET Gate Bias Resister | R1I | " | 30 | 0.002 | 0.001 | 7.175 | 4.900 |
| PMOSFET Gate Bias Resister | R2I | " | 30 | 0.000 | 0.000 | 7.400 | 4.900 |
| NMOSFET Gate Protection Resister | R3I | " | 30 | 0.003 | 0.003 | 7.225 | 4.325 |
| PMOSFET | T1I | " | 30 | 0.001 | 0.001 | 7.775 | 5.000 |
| PMOSFET | T1I2 | " | 30 | 0.001 | 0.001 | 6.850 | 5.000 |
| NMOSFET | T2I | " | 30 | 0.000 | 0.000 | 7.775 | 4.400 |
| Pico Fuse | F1I | " | 100 | | | 6.475 | 5.075 |
| | | | | | | | |
| Inductor | I1J | TRICKLE A | ~0 | | | 8.400 | 3.475 |
| Transient Voltage Suppressor | TVS1J | " | ~0 | | | 7.297 | 4.050 |

EPS Switch Board

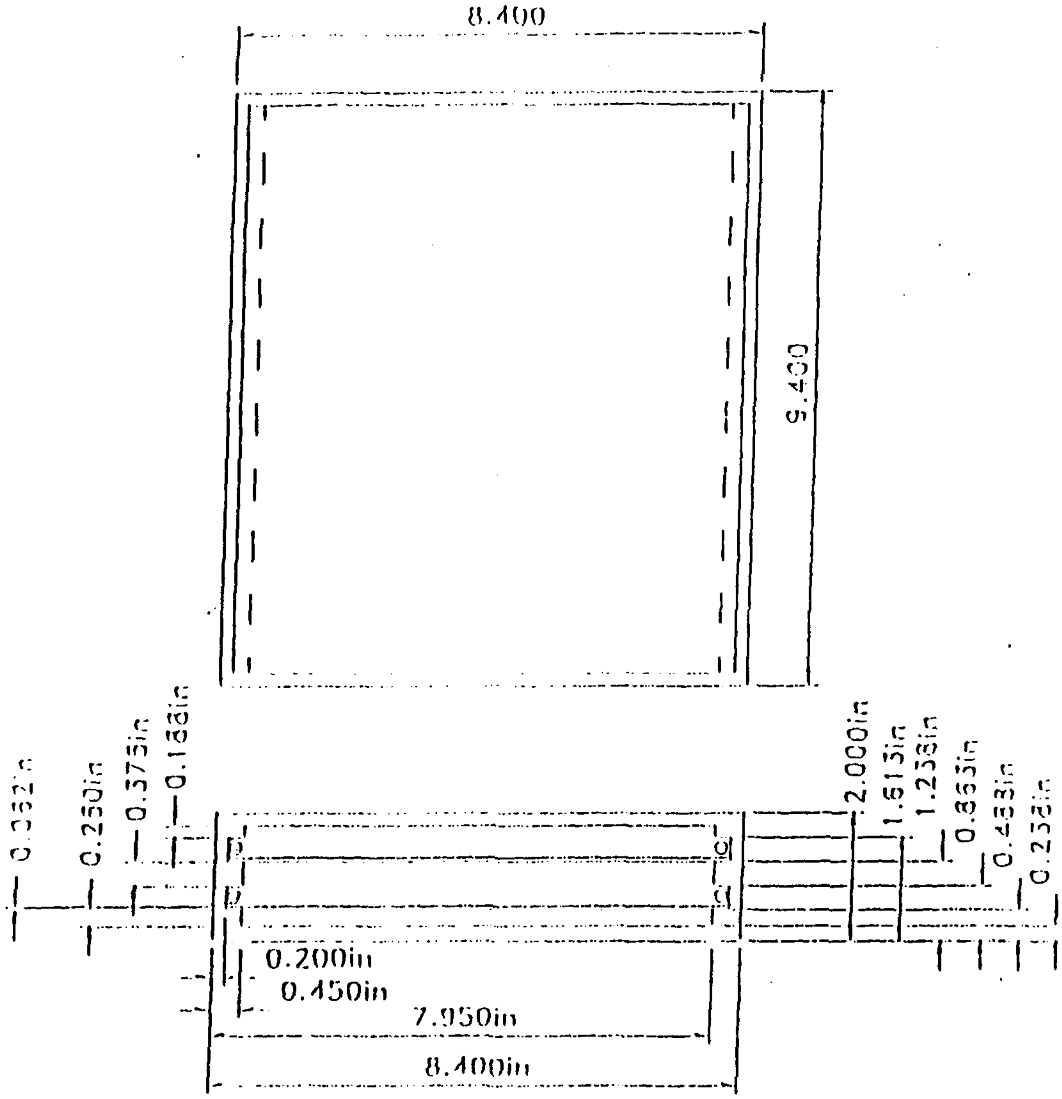
| Component | Designator | Subcircuit | Duty cycle | Power Dissipation, Bus = 15V (Sunlit) | Power Dissipation, Bus = 12V (Eclipse) | X-Coord | Y-Coord |
|---|---|---|---|---|---|---|---|
| Ultra Fast Recovery Diode | UFR1J | " | ~0 | | | 8.125 | 3.825 |
| 12v Zener Bi-Directional | D1J | " | ~0 | | | 7.175 | 3.150 |
| PMOSFET Gate Bias Resister | R1J | " | ~0 | | | 7.175 | 3.550 |
| PMOSFET Gate Bias Resister | R2J | " | ~0 | | | 7.400 | 3.550 |
| NMOSFET Gate Protection Resister | R3J | " | ~0 | | | 7.225 | 2.975 |
| PMOSFET | T1J | " | ~0 | | | 7.775 | 3.650 |
| PMOSFET | T1J2 | " | ~0 | | | 6.850 | 3.650 |
| NMOSFET | T2J | " | ~0 | | | 7.775 | 3.050 |
| Pico Fuse | F1J | " | ~0 | | | 6.475 | 3.725 |
| | | | | | | | |
| Inductor | I1K | TRICKLE B | ~0 | | | | |
| Transient Voltage Suppressor | TVS1K | " | ~0 | | | 8.400 | 2.100 |
| Ultra Fast Recovery Diode | UFR1K | " | ~0 | | | 7.297 | 2.675 |
| 12v Zener Bi-Directional | D1K | " | ~0 | | | 8.125 | 2.450 |
| PMOSFET Gate Bias Resister | R1K | " | ~0 | | | 7.175 | .775 |
| PMOSFET Gate Bias Resister | R2K | " | ~0 | | | 7.175 | 2.175 |
| NMOSFET Gate Bias Resister | R3K | " | ~0 | | | 7.400 | 2.175 |
| PMOSFET | T1K | " | ~0 | | | 7.225 | 1.600 |
| PMOSFET | T1K2 | " | ~0 | | | 7.775 | 2.275 |
| NMOSFET | T2K | " | ~0 | | | 6.850 | 2.275 |
| Pico Fuse | F1K | " | ~0 | | | 7.775 | 1.675 |
| | | | | | | 6.475 | 2.350 |
| NMOSFET | T3A | Discharge Battery A | | | | | |
| | | | | | | 5.750 | 5.300 |
| NMOSFET | T3B | Discharge Battery B | | | | | |
| | | | | | | 5.775 | 3.650 |
| LM150 | IS1A | Constant Current Source | | | | | |
| | | | | | | 3.975 | 3.092 |
| LM150 | IS1B | Constant Current Source | | | | | |
| | | | | | | 5.225 | 3.092 |
| | | | Total Power | 0.211W | 0.238W | | |


3.01
3.02
3.03
3.07
2.01
2.02
2.03
2.04
2.05
2.06
2.07
2.08
2.09
2.10
Z
X
Y

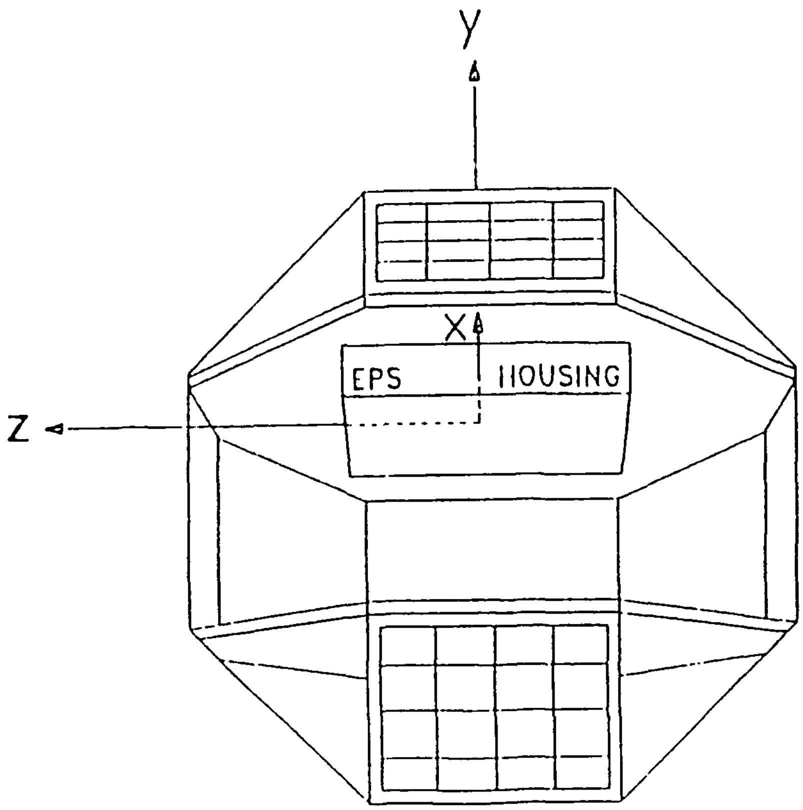

4.01
4.02
4.03
4.05
4.06
4.07
4.09
4.10
4.11
4.12
Z
X
Y

APPENDIX B

# EPS HOUSING



# EPS HOUSING LOCATION



# APPENDIX C ITAS SURFACE-NODE NUMBERS

PgDn PgUp Home End F2Help

ëëë Ctrl : Copy (See F2)ëë ITAS Property Data Entry ëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

| Seq | Surface No | NodeNo | Alpha | Emiss | T/Mass | Dissip | MID | Comments |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.01 | 1 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 2 | 1.02 | 2 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 3 | 1.03 | 3 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 4 | 1.04 | 4 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 5 | 1.05 | 5 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 6 | 1.06 | 6 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 7 | 1.07 | 7 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 8 | 1.08 | 8 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 9 | 1.09 | 9 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 10 | 1.10 | 10 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 11 | 1.11 | 11 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 12 | 1.12 | 12 | .4 | .8 | 1. | 0. | | EPS HOUSING |
| 13 | 2.01 | 13 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 14 | 2.02 | 14 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 15 | 2.03 | 15 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 16 | 2.04 | 16 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 17 | 2.05 | 17 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 18 | 2.06 | 18 | 0 | .01 | 1. | 0. | | PCB 1-1 |

S-F1Load/Save All S-F4Auto TM UDC Allowed ESCQuit

F1Load/Save Page F3PropLib F4AutoGen F5ImportPropFmt F6NewPropFile F10Search

PgDn PgUp Home End F2Help

ëëë Ctrl : Copy (See F2)ëë ITAS Property Data Entry ëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

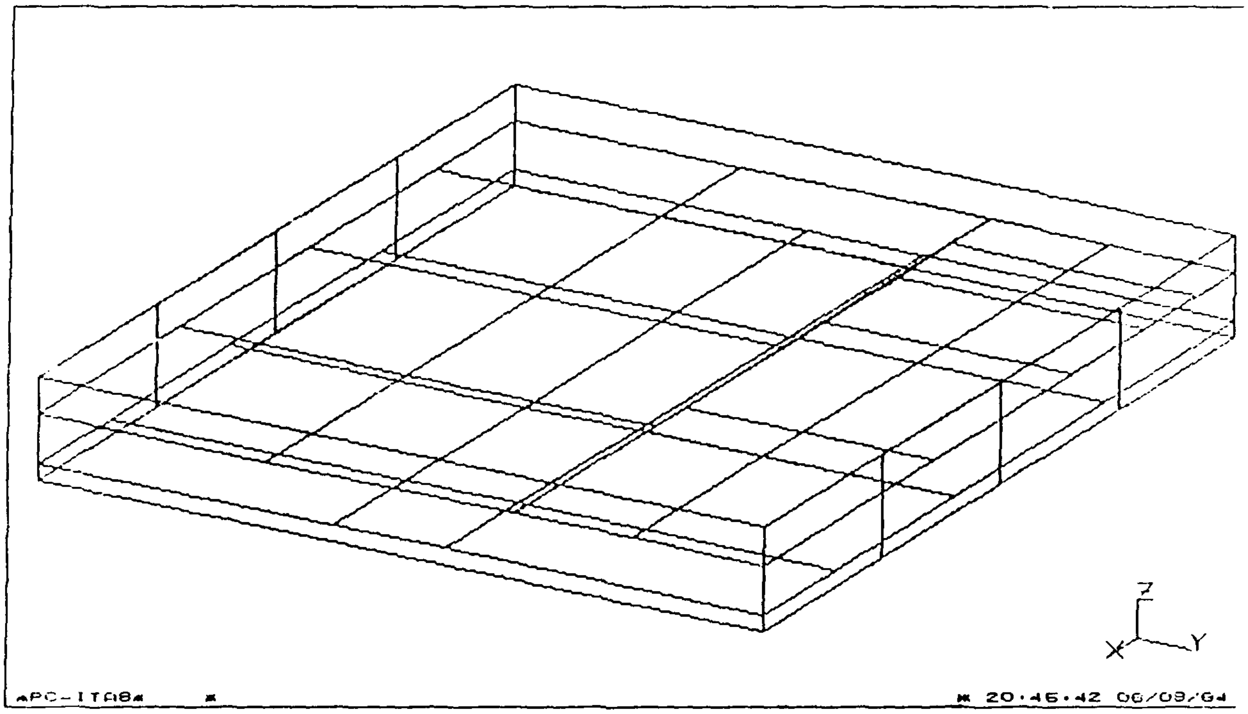
| Seq | Surface No | NodeNo | Alpha | Emiss | T/Mass | Dissip | MID | Comments |
|---|---|---|---|---|---|---|---|---|
| 19 | 2.07 | 19 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 20 | 2.08 | 20 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 21 | 2.09 | 21 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 22 | 2.10 | 22 | 0 | .01 | 1. | 0. | | PCB 1-1 |
| 23 | 3.01 | 23 | 0 | .01 | 1. | 0. | | PCB 1-2 |
| 24 | 3.02 | 24 | 0 | .01 | 1. | 0. | | PCB 1-2 |
| 25 | 3.03 | 25 | 0 | .01 | 1. | 0. | | PCB 1-2 |
| 26 | 3.04 | 26 | 0 | .01 | 1. | 0. | | PCB 1-2 |
| 27 | 3.05 | 27 | 0 | .01 | 1. | 0. | | PCB 1-2 |
| 28 | 3.06 | 28 | 0 | .01 | 1. | 0. | | PCB 1-2 |
| 29 | 3.07 | 29 | 0 | .01 | 1. | 0. | | PCB 1-2 |
| 30 | 3.08 | 30 | 0 | .01 | 1. | 0. | | PCB 1-2 |
| 31 | 4.01 | 31 | 0 | .01 | 1. | 0. | | PCB 2 (BOTTOM) |
| 32 | 4.02 | 32 | 0 | .01 | 1. | 0. | | PCB 2 (BOTTOM) |
| 33 | 4.03 | 33 | 0 | .01 | 1. | 0. | | PCB 2 (BOTTOM) |
| 34 | 4.04 | 34 | 0 | .01 | 1. | 0. | | PCB 2 (BOTTOM) |
| 35 | 4.05 | 35 | 0 | .01 | 1. | 0. | | PCB 2 (BOTTOM) |
| 36 | 4.06 | 36 | 0 | .01 | 1. | 0. | | PCB 2 (BOTTOM) |

S-F1Load/Save All S-F4Auto TM UDC Allowed ESCQuit

F1Load/Save Page F3PropLib F4AutoGen F5ImportPropFmt F6NewPropFile F10Search

```
PgDn PgUp Home End                                                     F2Help
èëë Ctrl : Copy (See F2)ëë ITAS Property Data Entry ëëëëëëëëëëëëëëëëëëëëëëëëë£
¤                                                                           ¤
¤ Seq Surface No NodeNo Alpha  Emiss  T/Mass Dissip MID  Comments           ¤
¤  25 3.03        25     0     .01    1.      0.          PCB 1-2           ¤
¤  26 3.04        26     0     .01    1.      0.          PCB 1-2           ¤
¤  27 3.05        27     0     .01    1.      0.          PCB 1-2           ¤
¤  28 3.06        28     0     .01    1.      0.          PCB 1-2           ¤
¤  29 3.07        29     0     .01    1.      0.          PCB 1-2           ¤
¤  30 3.08        30     0     .01    1.      0.          PCB 1-2           ¤
¤  31 4.01        31     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  32 4.02        32     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  33 4.03        33     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  34 4.04        34     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  35 4.05        35     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  36 4.06        36     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  37 4.07        37     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  38 4.08        38     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  39 4.09        39     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  40 4.10        40     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  41 4.11        41     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
¤  42 4.12        42     0     .01    1.      0.          PCB 2 (BOTTOM)    ¤
ÀëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëY
 S-F1Load/Save All          S-F4Auto TM    UDC Allowed                ESCQuit
   F1Load/Save Page F3PropLib F4AutoGen F5ImportPropFmt F6NewPropFile F10Search
```

# APPENDIX D EPS THERMAL MODEL SCHEMATIC



# APPENDIX E ITAS NODE CONDUCTANCES

Ctrl:Copy ITAS Conductor Data Entry ESC:Quit

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| | 1 | 1 | 901 | 1000 | L | GEO NODES-THERM NODES(HOUS) +X |
| | 1 | 2 | 902 | 1000 | L | +Y |
| | 1 | 3 | 903 | 1000 | L | +Y |
| | 1 | 4 | 904 | 1000 | L | +Y |
| | 1 | 5 | 905 | 1000 | L | +Y |
| | 1 | 6 | 906 | 1000 | L | +Z |
| | 1 | 7 | 907 | 1000 | L | -X |
| | 1 | 8 | 908 | 1000 | L | -Y |
| | 1 | 9 | 909 | 1000 | L | -Y |
| | 1 | 10 | 910 | 1000 | L | -Y |
| | 1 | 11 | 911 | 1000 | L | -Y |
| | 1 | 12 | 912 | 1000 | L | -Z |
| | 1 | 13 | 609 | 1000 | L | GEO NODES TO TOP PCB THERM LAYER |
| | 1 | 14 | 610 | 1000 | L | |
| | 1 | 15 | 611 | 1000 | L | |
| | 1 | 16 | 612 | 1000 | L | |
| | 1 | 17 | 613 | 1000 | L | |
| | 1 | 18 | 614 | 1000 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHIFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

Ctrl:Copy ITAS Conductor Data Entry ESC:Quit

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| | 1 | 19 | 615 | 1000 | L | |
| | 1 | 20 | 616 | 1000 | L | |
| | 1 | 21 | 617 | 1000 | L | |
| | 1 | 22 | 618 | 1000 | L | |
| | 1 | 23 | 601 | 1000 | L | |
| | 1 | 24 | 602 | 1000 | L | |
| | 1 | 25 | 603 | 1000 | L | |
| | 1 | 26 | 604 | 1000 | L | |
| | 1 | 27 | 605 | 1000 | L | |
| | 1 | 28 | 606 | 1000 | L | |
| | 1 | 29 | 607 | 1000 | L | |
| | 1 | 30 | 608 | 1000 | L | |
| | 1 | 31 | 1601 | 1000 | L | GEO NODES TO BOTTOM PCB THRM LYR |
| | 1 | 32 | 1602 | 1000 | L | |
| | 1 | 33 | 1603 | 1000 | L | |
| | 1 | 34 | 1604 | 1000 | L | |
| | 1 | 35 | 1605 | 1000 | L | |
| | 1 | 36 | 1606 | 1000 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHIFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £
¤                                                                            ¤
¤ SqNo FACTOR From    To     Cond. Value  L/R Description                    ¤
¤   37 1      37      1607   1000          L                                 ¤
¤   38 1      38      1608   1000          L                                 ¤
¤   39 1      39      1609   1000          L                                 ¤
¤   40 1      40      1610   1000          L                                 ¤
¤   41 1      41      1611   1000          L                                 ¤
¤   42 1      42      1612   1000          L                                 ¤
¤   43 1      -913    906    125.366       L   EPS HOUSING TO EQUIP PLATE    ¤
¤   44 1      901     905    .2638         L   HOUSING NODES TO HOUSING NODES ¤
¤   45 1      901     906    1.2592        L                                 ¤
¤   46 1      901     911    .2638         L                                 ¤
¤   47 1      901     912    1.2592        L                                 ¤
¤   48 1      902     903    .6011         L                                 ¤
¤   49 1      902     906    .3911         L                                 ¤
¤   50 1      902     907    .2638         L                                 ¤
¤   51 1      902     912    .3911         L                                 ¤
¤   52 1      903     904    .6011         L                                 ¤
¤   53 1      903     906    .3911         L                                 ¤
¤   54 1      903     912    .3911         L                                 ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëV
CTRL-F1Import ITAS_NC     ALT-F3AutoMLI    UDC Allowed             PgDn PgUp Home
SHFT-F1Import Column    Shift-F3AutoCHT   Shift-F5Del/Pur                 End
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £
¤                                                                            ¤
¤ SqNo FACTOR From    To     Cond. Value  L/R Description                    ¤
¤        1    904     905    .6011         L                                 ¤
¤        1    904     906    .3911         L                                 ¤
¤        1    904     912    .3911         L                                 ¤
¤        1    905     906    .3911         L                                 ¤
¤        1    905     912    .3911         L                                 ¤
¤        1    907     906    .3911         L                                 ¤
¤        1    907     908    .2638         L                                 ¤
¤        1    907     912    .3911         L                                 ¤
¤        1    908     906    .3911         L                                 ¤
¤        1    908     909    .6011         L                                 ¤
¤        1    908     912    .3911         L                                 ¤
¤        1    909     906    .3911         L                                 ¤
¤        1    909     910    .6011         L                                 ¤
¤        1    909     912    .3911         L                                 ¤
¤        1    910     906    .3911         L                                 ¤
¤        1    910     911    .6011         L                                 ¤
¤        1    910     912    .3911         L                                 ¤
¤        1    911     906    .3911         L                                 ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëV
CTRL-F1Import ITAS_NC     ALT-F3AutoMLI    UDC Allowed             PgDn PgUp Home
SHFT-F1Import Column    Shift-F3AutoCHT   Shift-F5Del/Pur                 End
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëë ESC:Quit £
¤                                                                              ¤
¤ SqNo FACTOR From   To     Cond. Value  L/R Description                       ¤
¤        1     911   912    .3911         L                                    ¤
¤        1     921   901    .5855         L   +Y BOTTOM RAIL TO HOUSING        ¤
¤        1     921   907    .5855         L                                    ¤
¤        1     921   908    10.775        L                                    ¤
¤        1     921   909    10.775        L                                    ¤
¤        1     921   910    10.775        L                                    ¤
¤        1     921   911    10.775        L                                    ¤
¤        1     921   912    39.7438       L                                    ¤
¤        1     922   901    .1611         L   +Y MIDDLE RAIL TO HOUSING        ¤
¤        1     922   907    .1611         L                                    ¤
¤        1     922   908    29.6528       L                                    ¤
¤        1     922   909    29.6528       L                                    ¤
¤        1     922   910    29.6528       L                                    ¤
¤        1     922   911    29.6528       L                                    ¤
¤        1     923   901    .1173         L   +Y TOP RAIL TO HOUSING           ¤
¤        1     923   907    .1173         L                                    ¤
¤        1     923   908    21.5921       L                                    ¤
¤        1     923   909    21.5921       L                                    ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëY
CTRL-F1Import ITAS_NC    ALT-F3AutoMLI    UDC Allowed            PgDn PgUp Home
SHFT-F1Import Column    Shift-F3AutoCHT   Shift-F5Del/Pur               End
    F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëë ESC:Quit £
¤                                                                              ¤
¤ SqNo FACTOR From   To     Cond. Value  L/R Description                       ¤
¤        1     923   910    21.5921       L                                    ¤
¤        1     923   911    21.5921       L                                    ¤
¤        1     923   906    27.9466       L                                    ¤
¤        1     924   901    .05855        L   -Y BOTTOM RAIL TO HOUSING        ¤
¤        1     924   907    .05855        L                                    ¤
¤        1     924   908    10.775        L                                    ¤
¤        1     924   909    10.775        L                                    ¤
¤        1     924   910    10.775        L                                    ¤
¤        1     924   911    10.775        L                                    ¤
¤        1     924   912    39.7438       L                                    ¤
¤        1     925   901    .1611         L   -Y MIDDLE RAIL TO HOUSING        ¤
¤        1     925   907    .1611         L                                    ¤
¤        1     925   908    29.6528       L                                    ¤
¤        1     925   909    29.6528       L                                    ¤
¤        1     925   910    29.6528       L                                    ¤
¤        1     925   911    29.6528       L                                    ¤
¤        1     926   901    .1173         L   -Y TOP RAIL TO HOUSING           ¤
¤        1     926   907    .1173         L                                    ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëY
CTRL-F1Import ITAS_NC    ALT-F3AutoMLI    UDC Allowed            PgDn PgUp Home
SHFT-F1Import Column    Shift-F3AutoCHT   Shift-F5Del/Pur               End
    F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| | 1 | 926 | 908 | 21.5921 | L | |
| | 1 | 926 | 909 | 21.5921 | L | |
| | 1 | 926 | 910 | 21.5921 | L | |
| | 1 | 926 | 911 | 21.5921 | L | |
| | 1 | 926 | 906 | 27.9466 | L | |
| | 1 | 1601 | 924 | 1.4967 | L | BOT PCB THRM LYR TO -Y BOT RAIL |
| | 1 | 1602 | 924 | 1.7213 | L | |
| | 1 | 1603 | 924 | 1.347 | L | |
| | 1 | 1604 | 924 | .8232 | L | |
| | 1 | 1609 | 921 | 1.4967 | L | BOT PCB THRM LYR TO +Y BOT RAIL |
| | 1 | 1610 | 921 | 1.7213 | L | |
| | 1 | 1611 | 921 | 1.347 | L | |
| | 1 | 1612 | 921 | .8232 | L | |
| | 1 | 1101 | 925 | .0027 | L | BOT PCB TP POLY LYR TO -Y MID RL |
| | 1 | 1102 | 925 | .0031 | L | |
| | 1 | 1103 | 925 | .0024 | L | |
| | 1 | 1104 | 925 | .0014 | L | |
| | 1 | 1109 | 922 | .0027 | L | BOT PCB TP POLY LYR TO +Y MID RL |

CTRL-F1Import ITAS_NC    ALT-F3AutoMLI    UDC Allowed    PgDn PgUp Home
SHIFT-F1Import Column    Shift-F3AutoCHT    Shift-F5Del/Pur    End
F1Save/Purge    F2Help F3AutoGen F4Purge F5Delete    F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| | 1 | 1110 | 922 | .0031 | L | |
| | 1 | 1111 | 922 | .0024 | L | |
| | 1 | 1112 | 922 | .0014 | L | |
| | 1 | 601 | 925 | .8007 | L | TOP PCB THRM LYR TO -Y MID RAIL |
| | 1 | 602 | 925 | 1.2811 | L | |
| | 1 | 603 | 925 | 1.2945 | L | |
| | 1 | 604 | 925 | 1.962 | L | |
| | 1 | 614 | 922 | .4003 | L | TOP PCB THRM LYR TO +Y MID RAIL |
| | 1 | 615 | 922 | .5338 | L | |
| | 1 | 616 | 922 | .7340 | L | |
| | 1 | 617 | 922 | 1.3986 | L | |
| | 1 | 618 | 922 | 1.7351 | L | |
| | 1 | 101 | 926 | .0016 | L | TOP PCB TP POLY LYR TO -Y TP RAIL |
| | 1 | 102 | 926 | .0026 | L | |
| | 1 | 103 | 926 | .0026 | L | |
| | 1 | 104 | 926 | .0039 | L | |
| | 1 | 114 | 923 | .0008 | L | |
| | 1 | 115 | 923 | .001 | L | |

CTRL-F1Import ITAS_NC    ALT-F3AutoMLI    UDC Allowed    PgDn PgUp Home
SHIFT-F1Import Column    Shift-F3AutoCHT    Shift-F5Del/Pur    End
F1Save/Purge    F2Help F3AutoGen F4Purge F5Delete    F7Mark/UnMark F10Search

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £
¤                                                                              ¤
¤ SqNo FACTOR From    To      Cond. Value   L/R Description                    ¤
¤       1     116     923     .0014          L                                 ¤
¤       1     117     923     .0028          L                                 ¤
¤       1     118     923     .0035          L                                 ¤
¤       1     601     602     .01657         L  TOP PCB THRM LYR NODE TO NODE  ¤
¤       1     601     605     .00738         L                                 ¤
¤       1     602     603     .0134          L                                 ¤
¤       1     602     606     .01183         L                                 ¤
¤       1     603     604     .01267         L                                 ¤
¤       1     603     607     .01194         L                                 ¤
¤       1     604     608     .01315         L                                 ¤
¤       1     605     606     .01825         L                                 ¤
¤       1     605     609     .00306         L                                 ¤
¤       1     605     610     .00306         L                                 ¤
¤       1     606     607     .01475         L                                 ¤
¤       1     606     610     .00159         L                                 ¤
¤       1     606     611     .00874         L                                 ¤
¤       1     606     612     .00493         L                                 ¤
¤       1     607     608     .01396         L                                 ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëV
CTRL-F1Import ITAS_NC     ALT-F3AutoMLI    UDC Allowed              PgDn PgUp Home
SHFT-F1Import Column     Shift-F3AutoCHT   Shift-F5Del/Pur                 End
     F1Save/Purge       F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £
¤                                                                              ¤
¤ SqNo FACTOR From    To      Cond. Value   L/R Description                    ¤
¤       1     607     612     .01177         L                                 ¤
¤       1     607     613     .00366         L                                 ¤
¤       1     608     613     .01702         L                                 ¤
¤       1     609     610     .0194          L                                 ¤
¤       1     609     614     .00452         L                                 ¤
¤       1     610     611     .0143          L                                 ¤
¤       1     610     615     .0094          L                                 ¤
¤       1     611     612     .00849         L                                 ¤
¤       1     611     616     .0129          L                                 ¤
¤       1     612     613     .00578         L                                 ¤
¤       1     612     617     .01156         L                                 ¤
¤       1     613     618     .03059         L                                 ¤
¤       1     615     614     .02128         L                                 ¤
¤       1     615     616     .01826         L                                 ¤
¤       1     617     616     .01084         L                                 ¤
¤       1     617     618     .01577         L                                 ¤
¤       1     401     402     .01657         L  TOP PCB GROUND LYR NODE TO NODE ¤
¤       1     401     405     .00738         L                                 ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëV
CTRL-F1Import ITAS_NC     ALT-F3AutoMLI    UDC Allowed              PgDn PgUp Home
SHFT-F1Import Column     Shift-F3AutoCHT   Shift-F5Del/Pur                 End
     F1Save/Purge       F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| | 1 | 402 | 403 | .0134 | L | |
| | 1 | 402 | 406 | .01183 | L | |
| | 1 | 403 | 404 | .01267 | L | |
| | 1 | 403 | 407 | .01194 | L | |
| | 1 | 404 | 408 | .01315 | L | |
| | 1 | 405 | 406 | .01825 | L | |
| | 1 | 405 | 409 | .00306 | L | |
| | 1 | 405 | 410 | .00306 | L | |
| | 1 | 406 | 407 | .01475 | L | |
| | 1 | 406 | 410 | .00159 | L | |
| | 1 | 406 | 411 | .00874 | L | |
| | 1 | 406 | 412 | .00493 | L | |
| | 1 | 407 | 408 | .01396 | L | |
| | 1 | 407 | 412 | .01177 | L | |
| | 1 | 407 | 413 | .00366 | L | |
| | 1 | 408 | 413 | .01702 | L | |
| | 1 | 409 | 410 | .0194 | L | |
| | 1 | 409 | 414 | .00452 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHIFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| | 1 | 410 | 411 | .0143 | L | |
| | 1 | 410 | 415 | .0094 | L | |
| | 1 | 411 | 412 | .00849 | L | |
| | 1 | 411 | 416 | .01291 | L | |
| | 1 | 412 | 413 | .00578 | L | |
| | 1 | 412 | 417 | .01156 | L | |
| | 1 | 413 | 418 | .03059 | L | |
| | 1 | 415 | 414 | .02128 | L | |
| | 1 | 415 | 416 | .01826 | L | |
| | 1 | 417 | 416 | .01084 | L | |
| | 1 | 417 | 418 | .01577 | L | |
| | 1 | 501 | 502 | .0001 | L | TOP PCB 5TH LYR NODETONODE-POLY |
| | 1 | 501 | 505 | .0001 | L | |
| | 1 | 502 | 503 | .0001 | L | |
| | 1 | 502 | 506 | .0001 | L | |
| | 1 | 503 | 504 | .0001 | L | |
| | 1 | 503 | 507 | .0001 | L | |
| | 1 | 504 | 508 | .0001 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHIFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 217 | 1 | 505 | 506 | .0001 | L | |
| 218 | 1 | 505 | 509 | .00003 | L | |
| 219 | 1 | 505 | 510 | .00003 | L | |
| 220 | 1 | 506 | 507 | .0001 | L | |
| 221 | 1 | 506 | 510 | .00001 | L | |
| 222 | 1 | 506 | 511 | .00006 | L | |
| 223 | 1 | 506 | 512 | .00003 | L | |
| 224 | 1 | 507 | 508 | .0001 | L | |
| 225 | 1 | 507 | 512 | .0001 | L | |
| 226 | 1 | 507 | 513 | .00003 | L | |
| 227 | 1 | 508 | 513 | .0001 | L | |
| 228 | 1 | 509 | 510 | .0001 | L | |
| 229 | 1 | 509 | 514 | .00005 | L | |
| 230 | 1 | 510 | 511 | .0001 | L | |
| 231 | 1 | 510 | 515 | .0001 | L | |
| 232 | 1 | 511 | 512 | .0001 | L | |
| 233 | 1 | 511 | 516 | .0001 | L | |
| 234 | 1 | 512 | 513 | .0001 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 235 | 1 | 512 | 517 | .0001 | L | |
| 236 | 1 | 513 | 518 | .00023 | L | |
| 237 | 1 | 515 | 514 | .0001 | L | |
| 238 | 1 | 515 | 516 | .0001 | L | |
| 239 | 1 | 517 | 516 | .0001 | L | |
| 240 | 1 | 517 | 518 | .0001 | L | |
| 241 | 1 | 601 | 501 | .0126 | L | TOP PCB LAYER TO LAYER |
| 242 | 1 | 602 | 502 | .0202 | L | |
| 243 | 1 | 603 | 503 | .0204 | L | |
| 244 | 1 | 604 | 504 | .0225 | L | |
| 245 | 1 | 605 | 505 | .0139 | L | |
| 246 | 1 | 606 | 506 | .0222 | L | |
| 247 | 1 | 607 | 507 | .0225 | L | |
| 248 | 1 | 608 | 508 | .0071 | L | |
| 249 | 1 | 609 | 509 | .0033 | L | |
| 250 | 1 | 610 | 510 | .0044 | L | |
| 251 | 1 | 611 | 511 | .006 | L | |
| 252 | 1 | 612 | 512 | .0117 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

Ctrl:Copy ITAS Conductor Data Entry ESC:Quit

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| | 1 | 613 | 513 | .0144 | L | |
| | 1 | 614 | 514 | .0036 | L | |
| | 1 | 615 | 515 | .0048 | L | |
| | 1 | 616 | 516 | .0066 | L | |
| | 1 | 617 | 517 | .0128 | L | |
| | 1 | 618 | 518 | .0157 | L | |
| | 1 | 501 | 401 | .0126 | L | |
| | 1 | 502 | 402 | .0202 | L | |
| | 1 | 503 | 403 | .0204 | L | |
| | 1 | 504 | 404 | .0225 | L | |
| | 1 | 505 | 405 | .0139 | L | |
| | 1 | 506 | 406 | .0222 | L | |
| | 1 | 507 | 407 | .0225 | L | |
| | 1 | 508 | 408 | .0071 | L | |
| | 1 | 509 | 409 | .0033 | L | |
| | 1 | 510 | 410 | .0044 | L | |
| | 1 | 511 | 411 | .006 | L | |
| | 1 | 512 | 412 | .0117 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

Ctrl:Copy ITAS Conductor Data Entry ESC:Quit

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 271 | 1 | 513 | 413 | .0144 | L | |
| 272 | 1 | 514 | 414 | .0036 | L | |
| 273 | 1 | 515 | 415 | .0048 | L | |
| 274 | 1 | 516 | 416 | .0066 | L | |
| 275 | 1 | 517 | 417 | .0128 | L | |
| 276 | 1 | 518 | 418 | .0157 | L | |
| 277 | 1 | 401 | 301 | .0126 | L | |
| 278 | 1 | 402 | 302 | .0202 | L | |
| 279 | 1 | 403 | 303 | .0204 | L | |
| 280 | 1 | 404 | 304 | .0225 | L | |
| 281 | 1 | 405 | 305 | .0139 | L | |
| 282 | 1 | 406 | 306 | .0222 | L | |
| 283 | 1 | 407 | 307 | .0225 | L | |
| 284 | 1 | 408 | 308 | .0071 | L | |
| 285 | 1 | 409 | 309 | .0033 | L | |
| 286 | 1 | 410 | 310 | .0044 | L | |
| 287 | 1 | 411 | 311 | .006 | L | |
| 288 | 1 | 412 | 312 | .0117 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 289 | 1 | 413 | 313 | .0144 | L | |
| 290 | 1 | 414 | 314 | .0036 | L | |
| 291 | 1 | 415 | 315 | .0048 | L | |
| 292 | 1 | 416 | 316 | .0066 | L | |
| 293 | 1 | 417 | 317 | .0128 | L | |
| 294 | 1 | 418 | 318 | .0157 | L | |
| 295 | 1 | 301 | 201 | .0126 | L | |
| 296 | 1 | 302 | 202 | .0202 | L | |
| 297 | 1 | 303 | 203 | .0204 | L | |
| 298 | 1 | 304 | 204 | .0225 | L | |
| 299 | 1 | 305 | 205 | .0139 | L | |
| 300 | 1 | 306 | 206 | .0222 | L | |
| 301 | 1 | 307 | 207 | .0225 | L | |
| 302 | 1 | 308 | 208 | .0071 | L | |
| 303 | 1 | 309 | 209 | .0033 | L | |
| 304 | 1 | 310 | 210 | .0044 | L | |
| 305 | 1 | 311 | 211 | .006 | L | |
| 306 | 1 | 312 | 212 | .0117 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHIFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 307 | 1 | 313 | 213 | .0144 | L | |
| 308 | 1 | 314 | 214 | .0036 | L | |
| 309 | 1 | 315 | 215 | .0048 | L | |
| 310 | 1 | 316 | 216 | .0066 | L | |
| 311 | 1 | 317 | 217 | .0128 | L | |
| 312 | 1 | 318 | 218 | .0157 | L | |
| 313 | 1 | 201 | 101 | .0126 | L | |
| 314 | 1 | 202 | 102 | .0202 | L | |
| 315 | 1 | 203 | 103 | .0204 | L | |
| 316 | 1 | 204 | 104 | .0225 | L | |
| 317 | 1 | 205 | 105 | .0139 | L | |
| 318 | 1 | 206 | 106 | .0222 | L | |
| 319 | 1 | 207 | 107 | .0225 | L | |
| 320 | 1 | 208 | 108 | .0071 | L | |
| 321 | 1 | 209 | 109 | .0033 | L | |
| 322 | 1 | 210 | 110 | .0044 | L | |
| 323 | 1 | 211 | 111 | .006 | L | |
| 324 | 1 | 212 | 112 | .0117 | L | |

CTRL-F1Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHIFT-F1Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëë Ctrl·Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 325 | 1 | 213 | 113 | .0144 | L | |
| 326 | 1 | 214 | 114 | .0036 | L | |
| 327 | 1 | 215 | 115 | .0144 | L | |
| 328 | 1 | 216 | 116 | .0066 | L | |
| 329 | 1 | 217 | 117 | .0128 | L | |
| 330 | 1 | 218 | 118 | .0157 | L | |
| 331 | 1 | 1601 | 1602 | .0168 | L | BOT PCB THRM LYR NODE TO NODE |
| 332 | 1 | 1601 | 1605 | .0136 | L | |
| 333 | 1 | 1602 | 1603 | .0176 | L | |
| 334 | 1 | 1602 | 1606 | .0156 | L | |
| 335 | 1 | 1603 | 1604 | .0249 | L | |
| 336 | 1 | 1603 | 1607 | .0122 | L | |
| 337 | 1 | 1604 | 1608 | .0074 | L | |
| 338 | 1 | 1605 | 1606 | .006 | L | |
| 339 | 1 | 1605 | 1609 | .0143 | L | |
| 340 | 1 | 1606 | 1607 | .0063 | L | |
| 341 | 1 | 1606 | 1610 | .0165 | L | |
| 342 | 1 | 1607 | 1608 | .0089 | L | |

CTRL-F1Import ITAS_NC   ALT-F3AutoMLI   UDC Allowed   PgDn PgUp Home
SHIFT-F1Import Column   Shift-F3AutoCHT   Shift-F5Del/Pur   End
F1Save/Purge   F2Help F3AutoGen F4Purge F5Delete   F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 343 | 1 | 1607 | 1611 | .0129 | L | |
| 344 | 1 | 1608 | 1612 | .0079 | L | |
| 345 | 1 | 1609 | 1610 | .0156 | L | |
| 346 | 1 | 1610 | 1611 | .0164 | L | |
| 347 | 1 | 1611 | 1612 | .0231 | L | |
| 348 | 1 | 1401 | 1402 | .0168 | L | BOT PCB GROUND LYR NODE TO NODE |
| 349 | 1 | 1401 | 1405 | .0136 | L | |
| 350 | 1 | 1402 | 1403 | .0176 | L | |
| 351 | 1 | 1402 | 1406 | .0156 | L | |
| 352 | 1 | 1403 | 1404 | .0249 | L | |
| 353 | 1 | 1403 | 1407 | .0122 | L | |
| 354 | 1 | 1404 | 1408 | .0074 | L | |
| 355 | 1 | 1405 | 1406 | .006 | L | |
| 356 | 1 | 1405 | 1409 | .0143 | L | |
| 357 | 1 | 1406 | 1407 | .0063 | L | |
| 358 | 1 | 1406 | 1410 | .0165 | L | |
| 359 | 1 | 1407 | 1408 | .0089 | L | |
| 360 | 1 | 1407 | 1411 | .0129 | L | |

CTRL-F1Import ITAS_NC   ALT-F3AutoMLI   UDC Allowed   PgDn PgUp Home
SHIFT-F1Import Column   Shift-F3AutoCHT   Shift-F5Del/Pur   End
F1Save/Purge   F2Help F3AutoGen F4Purge F5Delete   F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 361 | 1 | 1408 | 1412 | .0079 | L | |
| 362 | 1 | 1409 | 1410 | .0156 | L | |
| 363 | 1 | 1410 | 1411 | .0164 | L | |
| 364 | 1 | 1411 | 1412 | .0231 | L | |
| 365 | 1 | 1501 | 1502 | .0001 | L | BOT PCB 5TH LYR NODETONODE (POLY) |
| 366 | 1 | 1501 | 1505 | .0001 | L | |
| 367 | 1 | 1502 | 1503 | .0001 | L | |
| 368 | 1 | 1502 | 1506 | .0001 | L | |
| 369 | 1 | 1503 | 1504 | .0001 | L | |
| 370 | 1 | 1503 | 1507 | .0001 | L | |
| 371 | 1 | 1504 | 1508 | .0001 | L | |
| 372 | 1 | 1505 | 1506 | .0001 | L | |
| 373 | 1 | 1505 | 1509 | .0001 | L | |
| 374 | 1 | 1506 | 1507 | .0001 | L | |
| 375 | 1 | 1506 | 1510 | .0001 | L | |
| 376 | 1 | 1507 | 1508 | .0001 | L | |
| 377 | 1 | 1507 | 1511 | .0001 | L | |
| 378 | 1 | 1508 | 1512 | .0001 | L | |

CTRL-F1 Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHIFT-F1 Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £

| SqNo | FACTOR | From | To | Cond. Value | L/R | Description |
|---|---|---|---|---|---|---|
| 379 | 1 | 1509 | 1510 | .0001 | L | |
| 380 | 1 | 1510 | 1511 | .0001 | L | |
| 381 | 1 | 1511 | 1512 | .0001 | L | |
| 382 | 1 | 1601 | 1501 | .0295 | L | BOT PCB LAYER TO LAYER |
| 383 | 1 | 1602 | 1502 | .0339 | L | |
| 384 | 1 | 1603 | 1503 | .0266 | L | |
| 385 | 1 | 1604 | 1504 | .0162 | L | |
| 386 | 1 | 1605 | 1505 | .0105 | L | |
| 387 | 1 | 1606 | 1506 | .0121 | L | |
| 388 | 1 | 1607 | 1507 | .0095 | L | |
| 389 | 1 | 1608 | 1508 | .0058 | L | |
| 390 | 1 | 1609 | 1509 | .0274 | L | |
| 391 | 1 | 1610 | 1510 | .0315 | L | |
| 392 | 1 | 1611 | 1511 | .0247 | L | |
| 393 | 1 | 1612 | 1512 | .015 | L | |
| 394 | 1 | 1501 | 1401 | .0295 | L | |
| 395 | 1 | 1502 | 1402 | .0339 | L | |
| 396 | 1 | 1503 | 1403 | .0266 | L | |

CTRL-F1 Import ITAS_NC ALT-F3AutoMLI UDC Allowed PgDn PgUp Home
SHIFT-F1 Import Column Shift-F3AutoCHT Shift-F5Del/Pur End
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £
¤                                                                              ¤
¤ SqNo FACTOR From    To      Cond. Value   L/R Description                    ¤
¤   397 1      1504    1404    .0162          L                                ¤
¤   398 1      1505    1405    .0105          L                                ¤
¤   399 1      1506    1406    .0121          L                                ¤
¤   400 1      1507    1407    .0095          L                                ¤
¤   401 1      1508    1408    .0058          L                                ¤
¤   402 1      1509    1409    .0274          L                                ¤
¤   403 1      1510    1410    .0315          L                                ¤
¤   404 1      1511    1411    .0247          L                                ¤
¤   405 1      1512    1412    .015           L                                ¤
¤   406 1      1401    1301    .0295          L                                ¤
¤   407 1      1402    1302    .0339          L                                ¤
¤   408 1      1403    1303    .0266          L                                ¤
¤   409 1      1404    1304    .0162          L                                ¤
¤   410 1      1405    1305    .0105          L                                ¤
¤   411 1      1406    1306    .0121          L                                ¤
¤   412 1      1407    1307    .0095          L                                ¤
¤   413 1      1408    1308    .0058          L                                ¤
¤   414 1      1409    1309    .0274          L                                ¤
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CTRL-F1Import ITAS_NC     ALT-F3AutoMLI    UDC Allowed              PgDn PgUp Home
SHIFT-F1Import Column   Shift-F3AutoCHT   Shift-F5Del/Pur                End
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £
¤                                                                              ¤
¤ SqNo FACTOR From    To      Cond. Value   L/R Description                    ¤
¤   415 1      1410    1310    .0315          L                                ¤
¤   416 1      1411    1311    .0247          L                                ¤
¤   417 1      1412    1312    .015           L                                ¤
¤   418 1      1301    1201    .0295          L                                ¤
¤   419 1      1302    1202    .0339          L                                ¤
¤   420 1      1303    1203    .0266          L                                ¤
¤   421 1      1304    1204    .0162          L                                ¤
¤   422 1      1305    1205    .0105          L                                ¤
¤   423 1      1306    1206    .0121          L                                ¤
¤   424 1      1307    1207    .0095          L                                ¤
¤   425 1      1308    1208    .0058          L                                ¤
¤   426 1      1309    1209    .0274          L                                ¤
¤   427 1      1310    1210    .0315          L                                ¤
¤   428 1      1311    1211    .0247          L                                ¤
¤   429 1      1312    1212    .015           L                                ¤
¤   430 1      1201    1101    .0295          L                                ¤
¤   431 1      1202    1102    .0339          L                                ¤
¤   432 1      1203    1103    .0266          L                                ¤
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CTRL-F1Import ITAS_NC     ALT-F3AutoMLI    UDC Allowed              PgDn PgUp Home
SHIFT-F1Import Column   Shift-F3AutoCHT   Shift-F5Del/Pur                End
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
èëë Ctrl:Copyëëëëëëëëëëëëë ITAS Conductor Data Entry ëëëëëëëëëëëëëëë ESC:Quit £
¤                                                                               ¤
¤ SqNo FACTOR From   To     Cond. Value  L/R Description                        ¤
¤  433 1      1204   1104   .0162         L                                     ¤
¤  434 1      1205   1105   .0105         L                                     ¤
¤  435 1      1206   1106   .0121         L                                     ¤
¤  436 1      1207   1107   .0095         L                                     ¤
¤  437 1      1208   1108   .0058         L                                     ¤
¤  438 1      1209   1109   .0274         L                                     ¤
¤  439 1      1210   1110   .0315         L                                     ¤
¤  440 1      1211   1111   .0247         L                                     ¤
¤  441 1      1212   1112   .015          L                                     ¤
¤      1                                  L                                     ¤
¤      1                                  L                                     ¤
¤      1                                  L                                     ¤
¤      1                                  L                                     ¤
¤      1                                  L                                     ¤
¤      1                                  L                                     ¤
¤      1                                  L                                     ¤
¤      1                                  L                                     ¤
¤      1                                  L                                     ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëY
CTRL-F1Import ITAS_NC    ALT-F3AutoMLI   UDC Allowed                PgDn PgUp Home
SHFT-F1Import Column   Shift-F3AutoCHT   Shift-F5Del/Pur                  End
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

# APPENDIX F ITAS NODE DATA FOR COLD-CASE

Ctrl:Copy ITAS Node Data Entry For Thermal Analysis ESC:Quit

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| | 901 | 20 | | 0 | EPS HOUSING WALLS +X |
| | 902 | 20 | | 0 | +Y |
| | 903 | 20 | | 0 | +Y |
| | 904 | 20 | | 0 | +Y |
| | 905 | 20 | | 0 | +Y |
| | 906 | 20 | | 0 | +Z |
| | 907 | 20 | | 0 | -X |
| | 908 | 20 | | 0 | -Y |
| | 909 | 20 | | 0 | -Y |
| | 910 | 20 | | 0 | -Y |
| | 911 | 20 | | 0 | -Y |
| | 912 | 20 | | 0 | -Z |
| | -913 | 0 | | 0 | BOUNDARY NODE TO 906 |
| | 921 | 20 | | 0 | HOUSING +Y BOTTOM RAIL |
| | 922 | 20 | | 0 | +Y MIDDLE RAIL |
| | 923 | 20 | | 0 | +Y TOP RAIL |
| | 924 | 20 | | 0 | -Y BOTTOM RAIL |
| | 925 | 20 | | 0 | -Y MIDDLE RAIL |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

Ctrl:Copy ITAS Node Data Entry For Thermal Analysis ESC:Quit

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| | 926 | 20 | | 0 | -Y TOP RAIL |
| | 601 | 20 | | .058 | TOP PCB THERMAL PLANE |
| | 602 | 20 | | .070 | |
| | 603 | 20 | | .026 | |
| | 604 | 20 | | .001 | |
| | 605 | 20 | | 0 | |
| | 606 | 20 | | 0 | |
| | 607 | 20 | | 0 | |
| | 608 | 20 | | 0 | |
| | 609 | 20 | | 0 | |
| | 610 | 20 | | 0 | |
| | 611 | 20 | | 0 | |
| | 612 | 20 | | 0 | |
| | 613 | 20 | | 0 | |
| | 614 | 20 | | 0 | |
| | 615 | 20 | | 0 | |
| | 616 | 20 | | 0 | |
| | 617 | 20 | | 0 | |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

```
èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitë£
```

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| 37 | 618 | 20 | | 0 | |
| 38 | 501 | 20 | | 0 | 5TH LAYER POLYIMIDE |
| 39 | 502 | 20 | | 0 | |
| 40 | 503 | 20 | | 0 | |
| 41 | 504 | 20 | | 0 | |
| 42 | 505 | 20 | | 0 | |
| 43 | 506 | 20 | | 0 | |
| 44 | 507 | 20 | | 0 | |
| 45 | 508 | 20 | | 0 | |
| 46 | 509 | 20 | | 0 | |
| 47 | 510 | 20 | | 0 | |
| 48 | 511 | 20 | | 0 | |
| 49 | 512 | 20 | | 0 | |
| 50 | 513 | 20 | | 0 | |
| 51 | 514 | 20 | | 0 | |
| 52 | 515 | 20 | | 0 | |
| 53 | 516 | 20 | | 0 | |
| 54 | 517 | 20 | | 0 | |

```
CTRL-F1Import ITAS_NC   UDC Allowed                      PgDn PgUp Home End
SHFT-F1Import Column                   Shift-F5Del/Pur
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete   F7Mark/UnMark F10Search
```

```
èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitë£
```

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| | 518 | 20 | | | |
| | 401 | 20 | | .003 | GROUND LAYER COPPER |
| | 402 | 20 | | .004 | |
| | 403 | 20 | | .001 | |
| | 404 | 20 | | .001 | |
| | 405 | 20 | | 0 | |
| | 406 | 20 | | 0 | |
| | 407 | 20 | | 0 | |
| | 408 | 20 | | 0 | |
| | 409 | 20 | | 0 | |
| | 410 | 20 | | 0 | |
| | 411 | 20 | | 0 | |
| | 412 | 20 | | 0 | |
| | 413 | 20 | | 0 | |
| | 414 | 20 | | 0 | |
| | 415 | 20 | | 0 | |
| | 416 | 20 | | 0 | |
| | 417 | 20 | | 0 | |

```
CTRL-F1Import ITAS_NC   UDC Allowed                      PgDn PgUp Home End
SHFT-F1Import Column                   Shift-F5Del/Pur
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete   F7Mark/UnMark F10Search
```

```
èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitëë
n                                                                              n
n SEQN    NodeNo    Temp-C    ThrMass    Dissip    Comment                     n
n         418       20                   0                                     n
n         301       20                   0         3RD LAYER POLYIMIDE         n
n         302       20                   0                                     n
n         303       20                   0                                     n
n         304       20                   0                                     n
n         305       20                   0                                     n
n         306       20                   0                                     n
n         307       20                   0                                     n
n         308       20                   0                                     n
n         309       20                   0                                     n
n         310       20                   0                                     n
n         311       20                   0                                     n
n         312       20                   0                                     n
n         313       20                   0                                     n
n         314       20                   0                                     n
n         315       20                   0                                     n
n         316       20                   0                                     n
n         317       20                   0                                     n
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëY
CTRL-F1Import ITAS_NC    UDC Allowed                        PgDn PgUp Home End
SHFT-F1Import Column                     Shift-F5Del/Pur
     F1Save/Purge     F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitëë
n                                                                              n
n SEQN    NodeNo    Temp-C    ThrMass    Dissip    Comment                     n
n         318       20                   0                                     n
n         201       20                   0         SIGNAL LEVEL (VERY LITTLE CU) n
n         202       20                   0                                     n
n         203       20                   0                                     n
n         204       20                   0                                     n
n         205       20                   0                                     n
n         206       20                   0                                     n
n         207       20                   0                                     n
n         208       20                   0                                     n
n         209       20                   0                                     n
n         210       20                   0                                     n
n         211       20                   0                                     n
n         212       20                   0                                     n
n         213       20                   0                                     n
n         214       20                   0                                     n
n         215       20                   0                                     n
n         216       20                   0                                     n
n         217       20                   0                                     n
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëY
CTRL F1Import ITAS_NC    UDC Allowed                        PgDn PgUp Home End
SHFT-F1Import Column                     Shift-F5Del/Pur
     F1Save/Purge     F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
è8Ctrl:Copy8888888 ITAS Node Data Entry For Thermal Analysis 88888888ESC:Quit8£
¤                                                                              ¤
¤ SEQN     NodeNo    Temp-C    ThrMass   Dissip    Comment                     ¤
¤          218       20                  0                                     ¤
¤          101       20                  0         TOP LAYER POLYIMIDE         ¤
¤          102       20                  0                                     ¤
¤          103       20                  0                                     ¤
¤          104       20                  0                                     ¤
¤          105       20                  0                                     ¤
¤          106       20                  0                                     ¤
¤          107       20                  0                                     ¤
¤          108       20                  0                                     ¤
¤          109       20                  0                                     ¤
¤          110       20                  0                                     ¤
¤          111       20                  0                                     ¤
¤          112       20                  0                                     ¤
¤          113       20                  0                                     ¤
¤          114       20                  0                                     ¤
¤          115       20                  0                                     ¤
¤          116       20                  0                                     ¤
¤          117       20                  0                                     ¤
à888888888888888888888888888888888888888888888888888888888888888888888888888888¥
CTRL-F1Import ITAS_NC    UDC Allowed                       PgDn PgUp Home End
SHFT-F1Import Column                     Shift-F5Del/Pur
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
è8Ctrl:Copy8888888 ITAS Node Data Entry For Thermal Analysis 88888888ESC:Quit8£
¤                                                                              ¤
¤ SEQN     NodeNo    Temp-C    ThrMass   Dissip    Comment                     ¤
¤          118       20                  0                                     ¤
¤          1601      20                  0         BOTTOM PCB THERMAL PLANE COPPER ¤
¤          1602      20                  0                                     ¤
¤          1603      20                  0                                     ¤
¤          1604      20                  0                                     ¤
¤          1605      20                  0                                     ¤
¤          1606      20                  0                                     ¤
¤          1607      20                  0                                     ¤
¤          1608      20                  0                                     ¤
¤          1609      20                  0                                     ¤
¤          1610      20                  0                                     ¤
¤          1611      20                  0                                     ¤
¤          1612      20                  0                                     ¤
¤          1613      20                  0                                     ¤
¤          1614      20                  0                                     ¤
¤          1615      20                  0                                     ¤
¤          1616      20                  0                                     ¤
¤          1617      20                  0                                     ¤
à888888888888888888888888888888888888888888888888888888888888888888888888888888¥
CTRL-F1Import ITAS_NC    UDC Allowed                       PgDn PgUp Home End
SHFT-F1Import Column                     Shift-F5Del/Pur
     F1Save/Purge      F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitëf

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| | 1618 | 20 | | 0 | |
| | 1501 | 20 | | 0 | 5TH LAYER POLYIMIDE |
| | 1502 | 20 | | 0 | |
| | 1503 | 20 | | 0 | |
| | 1504 | 20 | | 0 | |
| | 1505 | 20 | | 0 | |
| | 1506 | 20 | | 0 | |
| | 1507 | 20 | | 0 | |
| | 1508 | 20 | | 0 | |
| | 1509 | 20 | | 0 | |
| | 1510 | 20 | | 0 | |
| | 1511 | 20 | | 0 | |
| | 1512 | 20 | | 0 | |
| | 1513 | 20 | | 0 | |
| | 1514 | 20 | | 0 | |
| | 1515 | 20 | | 0 | |
| | 1516 | 20 | | 0 | |
| | 1517 | 20 | | 0 | |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitëf

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| | 1518 | 20 | | 0 | |
| | 1401 | 20 | | 0 | GROUND LAYER COPPER |
| | 1402 | 20 | | 0 | |
| | 1403 | 20 | | 0 | |
| | 1404 | 20 | | 0 | |
| | 1405 | 20 | | 0 | |
| | 1406 | 20 | | 0 | |
| | 1407 | 20 | | 0 | |
| | 1408 | 20 | | 0 | |
| | 1409 | 20 | | 0 | |
| | 1410 | 20 | | 0 | |
| | 1411 | 20 | | 0 | |
| | 1412 | 20 | | 0 | |
| | 1413 | 20 | | 0 | |
| | 1414 | 20 | | 0 | |
| | 1415 | 20 | | 0 | |
| | 1416 | 20 | | 0 | |
| | 1417 | 20 | | 0 | |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitë£

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| | 1418 | 20 | | 0 | |
| | 1301 | 20 | | 0 | 3RD LAYER POLYIMIDE |
| | 1302 | 20 | | 0 | |
| | 1303 | 20 | | 0 | |
| | 1304 | 20 | | 0 | |
| | 1305 | 20 | | 0 | |
| | 1306 | 20 | | 0 | |
| | 1307 | 20 | | 0 | |
| | 1308 | 20 | | 0 | |
| | 1309 | 20 | | 0 | |
| | 1310 | 20 | | 0 | |
| | 1311 | 20 | | 0 | |
| | 1312 | 20 | | 0 | |
| | 1313 | 20 | | 0 | |
| | 1314 | 20 | | 0 | |
| | 1315 | 20 | | 0 | |
| | 1316 | 20 | | 0 | |
| | 1317 | 20 | | 0 | |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitë£

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| | 1318 | 20 | | 0 | |
| | 1201 | 20 | | 0 | SIGNAL LAYER COPPER |
| | 1202 | 20 | | 0 | |
| | 1203 | 20 | | 0 | |
| | 1204 | 20 | | 0 | |
| | 1205 | 20 | | 0 | |
| | 1206 | 20 | | 0 | |
| | 1207 | 20 | | 0 | |
| | 1208 | 20 | | 0 | |
| | 1209 | 20 | | 0 | |
| | 1210 | 20 | | 0 | |
| | 1211 | 20 | | 0 | |
| | 1212 | 20 | | 0 | |
| | 1213 | 20 | | 0 | |
| | 1214 | 20 | | 0 | |
| | 1215 | 20 | | 0 | |
| | 1216 | 20 | | 0 | |
| | 1217 | 20 | | 0 | |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

```
àëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitë£
n                                                                          ¤
n SEQN     NodeNo    Temp-C    ThrMass    Dissip    Comment                ¤
n          1218      20                   0                                ¤
n          1101      20                   0         TOP LAYER POLYIMIDE    ¤
n          1102      20                   0                                ¤
n          1103      20                   0                                ¤
n          1104      20                   0                                ¤
n          1105      20                   0                                ¤
n          1106      20                   0                                ¤
n          1107      20                   0                                ¤
n          1108      20                   0                                ¤
n          1109      20                   0                                ¤
n          1110      20                   0                                ¤
n          1111      20                   0                                ¤
n          1112      20                   0                                ¤
n          1113      20                   0                                ¤
n          1114      20                   0                                ¤
n          1115      20                   0                                ¤
n          1116      20                   0                                ¤
n          1117      20                   0                                ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëV
CTRL-F1Import ITAS_NC   UDC Allowed                    PgDn PgUp Home End
SHIFT-F1Import Column                      Shift-F5Del/Pur
     F1Save/Purge     F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

```
èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitë£
n                                                                          ¤
n SEQN     NodeNo    Temp-C    ThrMass    Dissip    Comment                ¤
n          1118      20                   0                                ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
n                                                                          ¤
àëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëV
CTRL-F1Import ITAS_NC   UDC Allowed                    PgDn PgUp Home End
SHIFT-F1Import Column                      Shift-F5Del/Pur
     F1Save/Purge     F2Help F3AutoGen F4Purge F5Delete  F7Mark/UnMark F10Search
```

# APPENDIX G ITAS NODE DATA FOR HOT-CASE

Ctrl:Copy ITAS Node Data Entry For Thermal Analysis ESC:Quit

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| 1 | 901 | 20 | | 0 | EPS HOUSING WALLS +X |
| 2 | 902 | 20 | | 0 | +Y |
| 3 | 903 | 20 | | 0 | +Y |
| 4 | 904 | 20 | | 0 | +Y |
| 5 | 905 | 20 | | 0 | +Y |
| 6 | 906 | 20 | | 0 | +Z |
| 7 | 907 | 20 | | 0 | -X |
| 8 | 908 | 20 | | 0 | -Y |
| 9 | 909 | 20 | | 0 | -Y |
| 10 | 910 | 20 | | 0 | -Y |
| 11 | 911 | 20 | | 0 | -Y |
| 12 | 912 | 20 | | 0 | -Z |
| 13 | -913 | 40 | | 0 | BOUNDARY NODE TO 906 |
| 14 | 921 | 20 | | 0 | HOUSING +Y BOTTOM RAIL |
| 15 | 922 | 20 | | 0 | +Y MIDDLE RAIL |
| 16 | 923 | 20 | | 0 | +Y TOP RAIL |
| 17 | 924 | 20 | | 0 | -Y BOTTOM RAIL |
| 18 | 925 | 20 | | 0 | -Y MIDDLE RAIL |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

Ctrl:Copy ITAS Node Data Entry For Thermal Analysis ESC:Quit

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| 19 | 926 | 20 | | 0 | -Y TOP RAIL |
| 20 | 601 | 20 | | .037 | TOP PCB THERMAL PLANE |
| 21 | 602 | 20 | | .0475 | |
| 22 | 603 | 20 | | .01995 | |
| 23 | 604 | 20 | | .01 | |
| 24 | 605 | 20 | | .011 | |
| 25 | 606 | 20 | | .060 | |
| 26 | 607 | 20 | | .011 | |
| 27 | 608 | 20 | | 0 | |
| 28 | 609 | 20 | | 0 | |
| 29 | 610 | 20 | | .008 | |
| 30 | 611 | 20 | | .008 | |
| 31 | 612 | 20 | | .011 | |
| 32 | 613 | 20 | | 0 | |
| 33 | 614 | 20 | | 0 | |
| 34 | 615 | 20 | | .009 | |
| 35 | 616 | 20 | | .009 | |
| 36 | 617 | 20 | | .004 | |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

èëCtrl:Copyëëëëëëë ITAS Node Data Entry For Thermal Analysis ëëëëëëëëESC:Quitëf

| SEQN | NodeNo | Temp-C | ThrMass | Dissip | Comment |
|---|---|---|---|---|---|
| 127 | 118 | 20 | | 0 | |
| 128 | 1601 | 20 | | .113 | BOTTOM PCB THERMAL PLANE COPPER |
| 129 | 1602 | 20 | | .086 | |
| 130 | 1603 | 20 | | .025 | |
| 131 | 1604 | 20 | | 0 | |
| 132 | 1605 | 20 | | 0 | |
| 133 | 1606 | 20 | | .175 | |
| 134 | 1607 | 20 | | 0 | |
| 135 | 1608 | 20 | | 0 | |
| 136 | 1609 | 20 | | .375 | |
| 137 | 1610 | 20 | | .105 | |
| 138 | 1611 | 20 | | .15 | |
| 139 | 1612 | 20 | | 0 | |
| 140 | 1613 | 20 | | 0 | |
| 141 | 1614 | 20 | | 0 | |
| 142 | 1615 | 20 | | 0 | |
| 143 | 1616 | 20 | | 0 | |
| 144 | 1617 | 20 | | 0 | |

CTRL-F1Import ITAS_NC UDC Allowed PgDn PgUp Home End
SHFT-F1Import Column Shift-F5Del/Pur
F1Save/Purge F2Help F3AutoGen F4Purge F5Delete F7Mark/UnMark F10Search

# APPENDIX H ITAS OUTPUT FOR COLD-CASE

```
 TOTAL SURFACES IN THIS MODEL=    42
 TOTAL SURFACES IN THIS MODEL=    42
*******************************************************************************
                       PC-ITAS Summary of Input Parameters
       These parameters reflect the latest values assigned to them
                         prior to any computation
 TOTAL SURFACES IN THIS MODEL=    42
*******************************************************************************
Date: 05/20/94                                              Time: 14:35:32.10
*******************************************************************************
===============================================================================
                        Thermal Analysis Parameters
===============================================================================
 1.  Solution Method:1.Steady-State 2.Transient 3. (1&2).......         1
 2.  Solution Time Step ........(minutes)......................      0.10
 3.  Final Time (minutes);if <0 then no of orbs................     -1.00
 4   Starting Temperature ......(Kelvin )......................    300.00
 5.  Temperature Print Interval (minutes)......................        20
 6.  No. of Iterations For Convergence (NLOOP).................      9999
 7.  Temperature Unit 1:K, 2:C, 3:F, 4:R.......................         2
 8.  Solution Accuracy Parameter (not used)....................       130
 9.  Solution Convergence Parameter (not used).................      1.30
 10. Solution Tolerance (ARLXCA, DRLXCA).......................   0.00100
 11. Transient Solution Stability Factor (not used)............     0.850
 12. Include User-Defined Network.......(Y/N)..................         Y
 13. Print RADK, POWER.................(Y/N)..................         N
 14. Print Transient Time/Temperature...(Y/N)..................         N
 15. Starting Temperatures Forced (No.4)(Y/N)...................         N
 16. Thermal Analyses Without Orbital Loads (Y/N)..............         Y
 17. Stand-Alone Thermal Analyzer (ITAS-Format Models).........         Y
 18. No. of Isolated Cavities (RADK files).....................         0

===============================================================================


/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
                           *ITAS THERMAL ANALYSIS*
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
 ITAS THERMAL ANALYZER:
 *ERROR*DATA ERROR ENCOUNTERED
*ERROR* FOR CODE=
 END OF RADIATION CONDUCTANCE & POWER PROCESSING
 THERMAL DATA PREP ERROR CODE=          1
*******************************************************************************
Date: 05/20/94                                              Time: 14:38:44.10
*******************************************************************************
===============================================================================
                        Thermal Analysis Parameters
===============================================================================
 1.  Solution Method:1.Steady-State 2.Transient 3. (1&2).......         1
 2.  Solution Time Step ........(minutes)......................      0.10
 3.  Final Time (minutes);if <0 then no of orbs................     -1.00
 4.  Starting Temperature ......(Kelvin )......................    300.00
 5.  Temperature Print Interval (minutes)......................        20
 6.  No. of Iterations For Convergence (NLOOP).................      9999
 7.  Temperature Unit 1:K, 2:C, 3:F, 4:R.......................         2
 8.  Solution Accuracy Parameter (not used)....................       130
 9.  Solution Convergence Parameter (not used).................      1.30
 10. Solution Tolerance (ARLXCA, DRLXCA).......................   0.00100
 11. Transient Solution Stability Factor (not used)............     0.850
```

```
 12. Include User-Defined Network.......(Y/N).................          Y
 13. Print RADK, POWER.................(Y/N).................          N
 14. Print Transient Time/Temperature...(Y/N).................          N
 15. Starting Temperatures Forced (No.4)(Y/N).................          N
 16. Thermal Analyses Without Orbital Loads (Y/N)..............          Y
 17. Stand-Alone Thermal Analyzer (ITAS-Format Models).........          N
 18. No. of Isolated Cavities (RADK files)....................          0

========================================================================

/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
                        *ITAS THERMAL ANALYSIS*
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
************************************************************************
Date: 05/20/94                                          Time: 14:38:44.10
************************************************************************
========================================================================
                  View Factor Computation Parameters
========================================================================
1. View Factor Accuracy Parameter...........................2
2. Engineering Units of the Geometry Data:
   1:inch, 2:feet, 3:centimeter, 4:meter.....................1
3. View Factor Computation Without Blockage (Y/N).............N
4. Print Control Parameters:
   0:Do Not Print; 1:Print All; 2:Print All & Intervener List.0
5. View-Factor Re-Start File.................................
========================================================================

/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
                     *ITAS VIEW FACTOR COMPUTATIONS*
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
 INPUT IS IN  INCHES
 OUTPUT IS IN CENTIMETERS
 TOTAL SURFACES IN THIS MODEL=   42


  UNITY MINUS THE SUM OF THE FACTORS
      (VIEW FACTOR -to- SPACE)
```

| SURFACE | 1.-FACT | KEY |
|---|---|---|
| 1.01 | 0.3965 | ( 3) |
| 1.02 | 0.3648 | ( 25) |
| 1.03 | 0.3930 | ( 26) |
| 1.04 | 0.3858 | ( 27) |
| 1.05 | 0.3524 | ( 28) |
| 1.06 | 0.8752 | ( 1) |
| 1.07 | 0.3811 | ( 4) |
| 1.08 | 0.3527 | ( 29) |
| 1.09 | 0.3855 | ( 30) |
| 1.10 | 0.3854 | ( 31) |
| 1.11 | 0.3524 | ( 32) |
| 1.12 | -0.0024 | ( 2) |
| 2.01 | 0.6859 | ( 42) |
| 2.02 | 0.8949 | ( 40) |
| 2.03 | 0.9450 | ( 37) |
| 2.04 | 0.9497 | ( 33) |
| 2.05 | 0.8709 | ( 20) |

```
          2.06       0.5751     (   41)
          2.07       0.7484     (   39)
          2.08       0.7874     (   36)
          2.09       0.7810     (   22)
          2.10       0.7203     (   18)
          3.01       0.7066     (   23)
          3.02       0.8437     (   16)
          3.03       0.8486     (   15)
          3.04       0.7683     (   12)
          3.05       0.7970     (   21)
          3.06       0.9587     (   14)
          3.07       0.9678     (   13)
          3.08       0.8683     (   10)
          4.01      -0.0193     (    8)
          4.02      -0.0115     (    6)
          4.03      -0.0117     (   11)
          4.04      -0.0154     (   19)
          4.05      -0.0348     (   34)
          4.06      -0.0001     (   24)
          4.07      -0.0003     (   35)
          4.08       0.0000     (   38)
          4.09      -0.0171     (    7)
          4.10      -0.0116     (    5)
          4.11      -0.0118     (    9)
          4.12      -0.0112     (   17)
 ACTIVE SURFACES IN OUTPUT-    42
*************************************
 VIEW FACTOR CALC CPU TIME (second) =      34.7100
*************************************
 ** END OF PC-ITAS VIEW FACTOR CALCULATIONS **
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/
********************************************************************************
Date: 05/20/94                                                Time: 14:39:19.10
********************************************************************************
================================================================================
                      Script-F Control Parameters
================================================================================
1. SPACE (SINK) Node Number.......................................       0
2. Cutoff Limit For Area*Script-F (Sq.cm.)....................0.5000E+00
3. Cutoff Limit For Blackbody Viewfactors.....................   0.0000
4. SPACE (SINK) Node Emissivity...............................   0.9999
5. SPACE (SINK) Node Temperature (Kelvin).....................   0.0000
6. SINDA-format RADK file to be generated (Y/N)...............        N
7. SINDA Radiation Conductor Number At Start..................   100000
8. Print control: 0:No,do not print, 1:Yes, print all.........        0
9. File name to store RADKs...................................EPS.RAD
================================================================================
```

| Seq | Surface No | Node No | Alpha | Emiss | T/Mass | Dissip | Matr ID |
|---|---|---|---|---|---|---|---|
| 1 | 1.01 | 1 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 2 | 1.02 | 2 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 3 | 1.03 | 3 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 4 | 1.04 | 4 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 5 | 1.05 | 5 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 6 | 1.06 | 6 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 7 | 1.07 | 7 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | 1.08 | 8 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 9 | 1.09 | 9 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 10 | 1.10 | 10 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 11 | 1.11 | 11 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 12 | 1.12 | 12 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 13 | 2.01 | 13 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 14 | 2.02 | 14 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 15 | 2.03 | 15 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 16 | 2.04 | 16 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 17 | 2.05 | 17 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 18 | 2.06 | 18 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 19 | 2.07 | 19 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 20 | 2.08 | 20 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 21 | 2.09 | 21 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 22 | 2.10 | 22 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 23 | 3.01 | 23 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 24 | 3.02 | 24 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 25 | 3.03 | 25 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 26 | 3.04 | 26 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 27 | 3.05 | 27 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 28 | 3.06 | 28 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 29 | 3.07 | 29 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 30 | 3.08 | 30 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 31 | 4.01 | 31 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 32 | 4.02 | 32 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 33 | 4.03 | 33 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 34 | 4.04 | 34 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 35 | 4.05 | 35 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 36 | 4.06 | 36 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 37 | 4.07 | 37 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 38 | 4.08 | 38 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 39 | 4.09 | 39 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 40 | 4.10 | 40 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 41 | 4.11 | 41 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 42 | 4.12 | 42 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |

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                    *ITAS SCRIPT-F (RADK) COMPUTATIONS*
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
PC-ITAS SCRIPT-F CALCULATION SEGMENT:
Writing ITAS-format RADK for future use
Node#,     Temp.,    TherMass,    Power
   1       10.00       1.00       0.00 EPS HOUSING
   2       10.00       1.00       0.00 EPS HOUSING
   3       10.00       1.00       0.00 EPS HOUSING
   4       10.00       1.00       0.00 EPS HOUSING
   5       10.00       1.00       0.00 EPS HOUSING
   6       10.00       1.00       0.00 EPS HOUSING
   7       10.00       1.00       0.00 EPS HOUSING
   8       10.00       1.00       0.00 EPS HOUSING
   9       10.00       1.00       0.00 EPS HOUSING
  10       10.00       1.00       0.00 EPS HOUSING
  11       10.00       1.00       0.00 EPS HOUSING
  12       10.00       1.00       0.00 EPS HOUSING
  13       10.00       1.00       0.00 PCB 1-1
  14       10.00       1.00       0.00 PCB 1-1
  15       10.00       1.00       0.00 PCB 1-1
  16       10.00       1.00       0.00 PCB 1-1
  17       10.00       1.00       0.00 PCB 1-1
  18       10.00       1.00       0.00 PCB 1-1
  19       10.00       1.00       0.00 PCB 1-1
```

| | | | | |
|---|---|---|---|---|
| 20 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 21 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 22 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 23 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 24 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 25 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 26 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 27 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 28 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 29 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 30 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 31 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 32 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 33 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 34 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 35 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 36 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 37 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 38 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 39 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 40 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 41 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 42 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |

| | | | | |
|---|---|---|---|---|
| RAD | 00 | 0.1295000000E+01 | 1 | 4 |
| RAD | 00 | 0.3408000000E+01 | 1 | 5 |
| RAD | 00 | 0.1231900000E+02 | 1 | 6 |
| RAD | 00 | 0.1441000000E+01 | 1 | 7 |
| RAD | 00 | 0.1166000000E+01 | 1 | 10 |
| RAD | 00 | 0.3754000000E+01 | 1 | 11 |
| RAD | 00 | 0.9037000000E+01 | 1 | 12 |
| RAD | 00 | 0.5500000000E+00 | 2 | 3 |
| RAD | 00 | 0.3313000000E+01 | 2 | 6 |
| RAD | 00 | 0.3342000000E+01 | 2 | 7 |
| RAD | 00 | 0.2634000000E+01 | 2 | 12 |
| RAD | 00 | 0.9950000000E+00 | 3 | 4 |
| RAD | 00 | 0.3602000000E+01 | 3 | 6 |
| RAD | 00 | 0.9060000000E+00 | 3 | 7 |
| RAD | 00 | 0.2767000000E+01 | 3 | 12 |
| RAD | 00 | 0.7580000000E+00 | 4 | 5 |
| RAD | 00 | 0.3602000000E+01 | 4 | 6 |
| RAD | 00 | 0.2770000000E+01 | 4 | 12 |
| RAD | 00 | 0.3314000000E+01 | 5 | 6 |
| RAD | 00 | 0.2622000000E+01 | 5 | 12 |
| RAD | 00 | 0.1230000000E+02 | 6 | 7 |
| RAD | 00 | 0.3314000000E+01 | 6 | 8 |
| RAD | 00 | 0.3600000000E+01 | 6 | 9 |
| RAD | 00 | 0.3601000000E+01 | 6 | 10 |
| RAD | 00 | 0.3314000000E+01 | 6 | 11 |
| RAD | 00 | 0.1643000000E+01 | 6 | 12 |
| RAD | 00 | 0.3619000000E+01 | 7 | 8 |
| RAD | 00 | 0.1020000000E+01 | 7 | 9 |
| RAD | 00 | 0.9591000000E+01 | 7 | 12 |
| RAD | 00 | 0.7800000000E+00 | 8 | 9 |
| RAD | 00 | 0.2629000000E+01 | 8 | 12 |
| RAD | 00 | 0.7910000000E+00 | 9 | 10 |
| RAD | 00 | 0.2762000000E+01 | 9 | 12 |
| RAD | 00 | 0.2766000000E+01 | 10 | 12 |
| RAD | 00 | 0.2615000000E+01 | 11 | 12 |
| RAD | 00 | 0.5660000000E+00 | 12 | 32 |
| RAD | 00 | 0.5110000000E+00 | 12 | 39 |

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RAD      00     0.6110000000E+00          12          40

 #OF RADIATION CONDUCTANCES GENERATED=    38
************************************
 SCRIPT-F CALC CPU TIME (second)    =     2.58000
************************************
 ITAS THERMAL ANALYZER:
vvvvvvvvvvvvvvvvvvv ADDING USER NODES vvvvvvvvvvv
IPTR_N= 5022
RECORD   5022=   1     901    20           0      EPS HOUSING WALLS +X
RECORD   5023=   2     902    20           0      +Y
RECORD   5024=   3     903    20           0      +Y
RECORD   5025=   4     904    20           0      +Y
RECORD   5026=   5     905    20           0      +Y
RECORD   5027=   6     906    20           0      +Z
RECORD   5028=   7     907    20           0      -X
RECORD   5029=   8     908    20           0      -Y
RECORD   5030=   9     909    20           0      -Y
RECORD   5031=  10     910    20           0      -Y
RECORD   5032=  11     911    20           0      -Y
RECORD   5033=  12     912    20           0      -Z
RECORD   5034=  13     -913   0            0      BOUNDARY NODE TO 906
RECORD   5035=  14     921    20           0      HOUSING +Y BOTTOM RAIL
RECORD   5036=  15     922    20           0      +Y MIDDLE RAIL
RECORD   5037=  16     923    20           0      +Y TOP RAIL
RECORD   5038=  17     924    20           0      -Y BOTTOM RAIL
RECORD   5039=  18     925    20           0      -Y MIDDLE RAIL
RECORD   5040=  19     926    20           0      -Y TOP RAIL
RECORD   5041=  20     601    20           .058   TOP PCB THERMAL PLANE
RECORD   5042=  21     602    20           .070
RECORD   5043=  22     603    20           .026
RECORD   5044=  23     604    20           .001
RECORD   5045=  24     605    20           0
RECORD   5046=  25     606    20           0
RECORD   5047=  26     607    20           0
RECORD   5048=  27     608    20           0
RECORD   5049=  28     609    20           0
RECORD   5050=  29     610    20           0
RECORD   5051=  30     611    20           0
RECORD   5052=  31     612    20           0
RECORD   5053=  32     613    20           0
RECORD   5054=  33     614    20           0
RECORD   5055=  34     615    20           0
RECORD   5056=  35     616    20           0
RECORD   5057=  36     617    20           0
RECORD   5058=  37     618    20           0
RECORD   5059=  38     501    20           0      5TH LAYER POLYIMIDE
RECORD   5060=  39     502    20           0
RECORD   5061=  40     503    20           0
RECORD   5062=  41     504    20           0
RECORD   5063=  42     505    20           0
RECORD   5064=  43     506    20           0
RECORD   5065=  44     507    20           0
RECORD   5066=  45     508    20           0
RECORD   5067=  46     509    20           0
RECORD   5068=  47     510    20           0
RECORD   5069=  48     511    20           0
RECORD   5070=  49     512    20           0
RECORD   5071=  50     513    20           0
RECORD   5072=  51     514    20           0
```

| | | | | | | |
|---|---|---|---|---|---|---|
| RECORD | 5073= | 52 | 515 | 20 | 0 | |
| RECORD | 5074= | 53 | 516 | 20 | 0 | |
| RECORD | 5075= | 54 | 517 | 20 | 0 | |
| RECORD | 5076= | 55 | 518 | 20 | | |
| RECORD | 5077= | 56 | 401 | 20 | .003 | GROUND LAYER COPPER |
| RECORD | 5078= | 57 | 402 | 20 | .004 | |
| RECORD | 5079= | 58 | 403 | 20 | .001 | |
| RECORD | 5080= | 59 | 404 | 20 | .001 | |
| RECORD | 5081= | 60 | 405 | 20 | 0 | |
| RECORD | 5082= | 61 | 406 | 20 | 0 | |
| RECORD | 5083= | 62 | 407 | 20 | 0 | |
| RECORD | 5084= | 63 | 408 | 20 | 0 | |
| RECORD | 5085= | 64 | 409 | 20 | 0 | |
| RECORD | 5086= | 65 | 410 | 20 | 0 | |
| RECORD | 5087= | 66 | 411 | 20 | 0 | |
| RECORD | 5088= | 67 | 412 | 20 | 0 | |
| RECORD | 5089= | 68 | 413 | 20 | 0 | |
| RECORD | 5090= | 69 | 414 | 20 | 0 | |
| RECORD | 5091= | 70 | 415 | 20 | 0 | |
| RECORD | 5092= | 71 | 416 | 20 | 0 | |
| RECORD | 5093= | 72 | 417 | 20 | 0 | |
| RECORD | 5094= | 73 | 418 | 20 | 0 | |
| RECORD | 5095= | 74 | 301 | 20 | 0 | 3RD LAYER POLYIMIDE |
| RECORD | 5096= | 75 | 302 | 20 | 0 | |
| RECORD | 5097= | 76 | 303 | 20 | 0 | |
| RECORD | 5098= | 77 | 304 | 20 | 0 | |
| RECORD | 5099= | 78 | 305 | 20 | 0 | |
| RECORD | 5100= | 79 | 306 | 20 | 0 | |
| RECORD | 5101= | 80 | 307 | 20 | 0 | |
| RECORD | 5102= | 81 | 308 | 20 | 0 | |
| RECORD | 5103= | 82 | 309 | 20 | 0 | |
| RECORD | 5104= | 83 | 310 | 20 | 0 | |
| RECORD | 5105= | 84 | 311 | 20 | 0 | |
| RECORD | 5106= | 85 | 312 | 20 | 0 | |
| RECORD | 5107= | 86 | 313 | 20 | 0 | |
| RECORD | 5108= | 87 | 314 | 20 | 0 | |
| RECORD | 5109= | 88 | 315 | 20 | 0 | |
| RECORD | 5110= | 89 | 316 | 20 | 0 | |
| RECORD | 5111= | 90 | 317 | 20 | 0 | |
| RECORD | 5112= | 91 | 318 | 20 | 0 | |
| RECORD | 5113= | 92 | 201 | 20 | 0 | SIGNAL LEVEL (VERY LITTLE CU) |
| RECORD | 5114= | 93 | 202 | 20 | 0 | |
| RECORD | 5115= | 94 | 203 | 20 | 0 | |
| RECORD | 5116= | 95 | 204 | 20 | 0 | |
| RECORD | 5117= | 96 | 205 | 20 | 0 | |
| RECORD | 5118= | 97 | 206 | 20 | 0 | |
| RECORD | 5119= | 98 | 207 | 20 | 0 | |
| RECORD | 5120= | 99 | 208 | 20 | 0 | |
| RECORD | 5121= | 100 | 209 | 20 | 0 | |
| RECORD | 5122= | 101 | 210 | 20 | 0 | |
| RECORD | 5123= | 102 | 211 | 20 | 0 | |
| RECORD | 5124= | 103 | 212 | 20 | 0 | |
| RECORD | 5125= | 104 | 213 | 20 | 0 | |
| RECORD | 5126= | 105 | 214 | 20 | 0 | |
| RECORD | 5127= | 106 | 215 | 20 | 0 | |
| RECORD | 5128= | 107 | 216 | 20 | 0 | |
| RECORD | 5129= | 108 | 217 | 20 | 0 | |
| RECORD | 5130= | 109 | 218 | 20 | 0 | |
| RECORD | 5131= | 110 | 101 | 20 | 0 | TOP LAYER POLYIMIDE |
| RECORD | 5132= | 111 | 102 | 20 | 0 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| RECORD | 5133= | 112 | 103 | 20 | 0 | |
| RECORD | 5134= | 113 | 104 | 20 | 0 | |
| RECORD | 5135= | 114 | 105 | 20 | 0 | |
| RECORD | 5136= | 115 | 106 | 20 | 0 | |
| RECORD | 5137= | 116 | 107 | 20 | 0 | |
| RECORD | 5138= | 117 | 108 | 20 | 0 | |
| RECORD | 5139= | 118 | 109 | 20 | 0 | |
| RECORD | 5140= | 119 | 110 | 20 | 0 | |
| RECORD | 5141= | 120 | 111 | 20 | 0 | |
| RECORD | 5142= | 121 | 112 | 20 | 0 | |
| RECORD | 5143= | 122 | 113 | 20 | 0 | |
| RECORD | 5144= | 123 | 114 | 20 | 0 | |
| RECORD | 5145= | 124 | 115 | 20 | 0 | |
| RECORD | 5146= | 125 | 116 | 20 | 0 | |
| RECORD | 5147= | 126 | 117 | 20 | 0 | |
| RECORD | 5148= | 127 | 118 | 20 | 0 | |
| RECORD | 5149= | 128 | 1601 | 20 | 0 | BOTTOM PCB THERMAL PLANE COPPER |
| RECORD | 5150= | 129 | 1602 | 20 | 0 | |
| RECORD | 5151= | 130 | 1603 | 20 | 0 | |
| RECORD | 5152= | 131 | 1604 | 20 | 0 | |
| RECORD | 5153= | 132 | 1605 | 20 | 0 | |
| RECORD | 5154= | 133 | 1606 | 20 | 0 | |
| RECORD | 5155= | 134 | 1607 | 20 | 0 | |
| RECORD | 5156= | 135 | 1608 | 20 | 0 | |
| RECORD | 5157= | 136 | 1609 | 20 | 0 | |
| RECORD | 5158= | 137 | 1610 | 20 | 0 | |
| RECORD | 5159= | 138 | 1611 | 20 | 0 | |
| RECORD | 5160= | 139 | 1612 | 20 | 0 | |
| RECORD | 5161= | 140 | 1613 | 20 | 0 | |
| RECORD | 5162= | 141 | 1614 | 20 | 0 | |
| RECORD | 5163= | 142 | 1615 | 20 | 0 | |
| RECORD | 5164= | 143 | 1616 | 20 | 0 | |
| RECORD | 5165= | 144 | 1617 | 20 | 0 | |
| RECORD | 5166= | 145 | 1618 | 20 | 0 | |
| RECORD | 5167= | 146 | 1501 | 20 | 0 | 5TH LAYER POLYIMIDE |
| RECORD | 5168= | 147 | 1502 | 20 | 0 | |
| RECORD | 5169= | 148 | 1503 | 20 | 0 | |
| RECORD | 5170= | 149 | 1504 | 20 | 0 | |
| RECORD | 5171= | 150 | 1505 | 20 | 0 | |
| RECORD | 5172= | 151 | 1506 | 20 | 0 | |
| RECORD | 5173= | 152 | 1507 | 20 | 0 | |
| RECORD | 5174= | 153 | 1508 | 20 | 0 | |
| RECORD | 5175= | 154 | 1509 | 20 | 0 | |
| RECORD | 5176= | 155 | 1510 | 20 | 0 | |
| RECORD | 5177= | 156 | 1511 | 20 | 0 | |
| RECORD | 5178= | 157 | 1512 | 20 | 0 | |
| RECORD | 5179= | 158 | 1513 | 20 | 0 | |
| RECORD | 5180= | 159 | 1514 | 20 | 0 | |
| RECORD | 5181= | 160 | 1515 | 20 | 0 | |
| RECORD | 5182= | 161 | 1516 | 20 | 0 | |
| RECORD | 5183= | 162 | 1517 | 20 | 0 | |
| RECORD | 5184= | 163 | 1518 | 20 | 0 | |
| RECORD | 5185= | 164 | 1401 | 20 | 0 | GROUND LAYER COPPER |
| RECORD | 5186= | 165 | 1402 | 20 | 0 | |
| RECORD | 5187= | 166 | 1403 | 20 | 0 | |
| RECORD | 5188= | 167 | 1404 | 20 | 0 | |
| RECORD | 5189= | 168 | 1405 | 20 | 0 | |
| RECORD | 5190= | 169 | 1406 | 20 | 0 | |
| RECORD | 5191= | 170 | 1407 | 20 | 0 | |
| RECORD | 5192= | 171 | 1408 | 20 | 0 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| RECORD | 5193= | 172 | 1409 | 20 | 0 | |
| RECORD | 5194= | 173 | 1410 | 20 | 0 | |
| RECORD | 5195= | 174 | 1411 | 20 | 0 | |
| RECORD | 5196= | 175 | 1412 | 20 | 0 | |
| RECORD | 5197= | 176 | 1413 | 20 | 0 | |
| RECORD | 5198= | 177 | 1414 | 20 | 0 | |
| RECORD | 5199= | 178 | 1415 | 20 | 0 | |
| RECORD | 5200= | 179 | 1416 | 20 | 0 | |
| RECORD | 5201= | 180 | 1417 | 20 | 0 | |
| RECORD | 5202= | 181 | 1418 | 20 | 0 | |
| RECORD | 5203= | 182 | 1301 | 20 | 0 | 3RD LAYER POLYIMIDE |
| RECORD | 5204= | 183 | 1302 | 20 | 0 | |
| RECORD | 5205= | 184 | 1303 | 20 | 0 | |
| RECORD | 5206= | 185 | 1304 | 20 | 0 | |
| RECORD | 5207= | 186 | 1305 | 20 | 0 | |
| RECORD | 5208= | 187 | 1306 | 20 | 0 | |
| RECORD | 5209= | 188 | 1307 | 20 | 0 | |
| RECORD | 5210= | 189 | 1308 | 20 | 0 | |
| RECORD | 5211= | 190 | 1309 | 20 | 0 | |
| RECORD | 5212= | 191 | 1310 | 20 | 0 | |
| RECORD | 5213= | 192 | 1311 | 20 | 0 | |
| RECORD | 5214= | 193 | 1312 | 20 | 0 | |
| RECORD | 5215= | 194 | 1313 | 20 | 0 | |
| RECORD | 5216= | 195 | 1314 | 20 | 0 | |
| RECORD | 5217= | 196 | 1315 | 20 | 0 | |
| RECORD | 5218= | 197 | 1316 | 20 | 0 | |
| RECORD | 5219= | 198 | 1317 | 20 | 0 | |
| RECORD | 5220= | 199 | 1318 | 20 | 0 | |
| RECORD | 5221= | 200 | 1201 | 20 | 0 | SIGNAL LAYER COPPER |
| RECORD | 5222= | 201 | 1202 | 20 | 0 | |
| RECORD | 5223= | 202 | 1203 | 20 | 0 | |
| RECORD | 5224= | 203 | 1204 | 20 | 0 | |
| RECORD | 5225= | 204 | 1205 | 20 | 0 | |
| RECORD | 5226= | 205 | 1206 | 20 | 0 | |
| RECORD | 5227= | 206 | 1207 | 20 | 0 | |
| RECORD | 5228= | 207 | 1208 | 20 | 0 | |
| RECORD | 5229= | 208 | 1209 | 20 | 0 | |
| RECORD | 5230= | 209 | 1210 | 20 | 0 | |
| RECORD | 5231= | 210 | 1211 | 20 | 0 | |
| RECORD | 5232= | 211 | 1212 | 20 | 0 | |
| RECORD | 5233= | 212 | 1213 | 20 | 0 | |
| RECORD | 5234= | 213 | 1214 | 20 | 0 | |
| RECORD | 5235= | 214 | 1215 | 20 | 0 | |
| RECORD | 5236= | 215 | 1216 | 20 | 0 | |
| RECORD | 5237= | 216 | 1217 | 20 | 0 | |
| RECORD | 5238= | 217 | 1218 | 20 | 0 | |
| RECORD | 5239= | 218 | 1101 | 20 | 0 | TOP LAYER POLYIMIDE |
| RECORD | 5240= | 219 | 1102 | 20 | 0 | |
| RECORD | 5241= | 220 | 1103 | 20 | 0 | |
| RECORD | 5242= | 221 | 1104 | 20 | 0 | |
| RECORD | 5243= | 222 | 1105 | 20 | 0 | |
| RECORD | 5244= | 223 | 1106 | 20 | 0 | |
| RECORD | 5245= | 224 | 1107 | 20 | 0 | |
| RECORD | 5246= | 225 | 1108 | 20 | 0 | |
| RECORD | 5247= | 226 | 1109 | 20 | 0 | |
| RECORD | 5248= | 227 | 1110 | 20 | 0 | |
| RECORD | 5249= | 228 | 1111 | 20 | 0 | |
| RECORD | 5250= | 229 | 1112 | 20 | 0 | |
| RECORD | 5251= | 230 | 1113 | 20 | 0 | |
| RECORD | 5252= | 231 | 1114 | 20 | 0 | |

```
RECORD  5253= 232     1115  20          0
RECORD  5254= 233     1116  20          0
RECORD  5255= 234     1117  20          0
RECORD  5256= 235     1118  20          0
^^^^^^^^^^^^^^^^^^^^ END OF USER NODES ^^^^^^^^^^
^^^^^^^^^^^^^^^^^^ END OF FLUID ^^^^^^^^^^^^^^^^
 TOTAL THERMAL MASS ENCOUNTERED (W-MIN/C)=     1329.04
 TOTAL THERMAL MASS ENCOUNTERED (BTU  /F)=     42.0002
^^^^^^^^^^^^^^^^^^ END OF FLUID ^^^^^^^^^^^^^^^^
 NODE       1 (REL NODE       1 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       2 (REL NODE       2 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       3 (REL NODE       3 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       4 (REL NODE       4 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       5 (REL NODE       5 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       6 (REL NODE       6 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       7 (REL NODE       7 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       8 (REL NODE       8 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       9 (REL NODE       9 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      10 (REL NODE      10 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      11 (REL NODE      11 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      12 (REL NODE      12 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      13 (REL NODE      13 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      14 (REL NODE      14 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      15 (REL NODE      15 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      16 (REL NODE      16 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      17 (REL NODE      17 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      18 (REL NODE      18 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      19 (REL NODE      19 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      20 (REL NODE      20 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      21 (REL NODE      21 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      22 (REL NODE      22 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      23 (REL NODE      23 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      24 (REL NODE      24 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      25 (REL NODE      25 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      26 (REL NODE      26 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      27 (REL NODE      27 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      28 (REL NODE      28 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      29 (REL NODE      29 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      30 (REL NODE      30 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      31 (REL NODE      31 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      32 (REL NODE      32 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      33 (REL NODE      33 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      34 (REL NODE      34 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      35 (REL NODE      35 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      36 (REL NODE      36 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      37 (REL NODE      37 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      38 (REL NODE      38 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      39 (REL NODE      39 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      40 (REL NODE      40 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      41 (REL NODE      41 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      42 (REL NODE      42 ) IS BEING ADDED TO THE CURRENT LIST
END OF RADIATION CONDUCTANCE & POWER PROCESSING
ITAS THERMAL ANALYSIS:


CHECKOUT PHASE OF PC-ITAS THERMAL ANALYSIS

TOTAL CARDS ENCOUNTERED:    1760
TOTAL THERMAL MASSES USED (W-Min/C)=      1366.04
TOTAL THERMAL MASSES USED (BTU/F  )=      43.1695
```

NO. OF THERMAL NODES= 277

ITAS STEADY-STATE SOLUTION ALGORITHM (SUCCESSIVE POINT ITERATION) PARAMETERS:
ARLXCA=0.10000E-02, DRLXCA=0.10000E-02 NLOOP= 9999

ITAS STEADY-STATE SOLUTION (SUCCESSIVE POINT ITERATION)
NO. OF ITERATIONS= 2588 TOTAL INPUT ENERGY (W)= 0.16400
SYSTEM ENERGY BALANCE (W)= -8.0523 ( 4909.9 %)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| T 1= | 0.43 | T 2= | 0.80 | T 3= | 0.83 | T 4= | 0.83 |
| T 5= | 0.77 | T 6= | 0.12 | T 7= | 0.56 | T 8= | 0.44 |
| T 9= | 0.44 | T 10= | 0.44 | T 11= | 0.44 | T 12= | 0.51 |
| T 13= | 19.79 | T 14= | 19.59 | T 15= | 19.39 | T 16= | 19.33 |
| T 17= | 18.55 | T 18= | 3.13 | T 19= | 2.51 | T 20= | 1.55 |
| T 21= | 0.87 | T 22= | 0.97 | T 23= | 1.38 | T 24= | 1.03 |
| T 25= | 0.97 | T 26= | 0.75 | T 27= | 19.60 | T 28= | 19.24 |
| T 29= | 19.25 | T 30= | 19.27 | T 31= | 0.88 | T 32= | 0.86 |
| T 33= | 0.97 | T 34= | 1.30 | T 35= | 18.46 | T 36= | 18.33 |
| T 37= | 18.87 | T 38= | 19.28 | T 39= | 0.88 | T 40= | 0.86 |
| T 41= | 0.96 | T 42= | 1.26 | T 901= | 0.43 | T 902= | 0.80 |
| T 903= | 0.83 | T 904= | 0.83 | T 905= | 0.77 | T 906= | 0.12 |
| T 907= | 0.56 | T 908= | 0.44 | T 909= | 0.44 | T 910= | 0.44 |
| T 911= | 0.44 | T 912= | 0.51 | T 913= | 0.00 | T 921= | 0.50 |
| T 922= | 0.47 | T 923= | 0.36 | T 924= | 0.50 | T 925= | 0.46 |
| T 926= | 0.36 | T 601= | 1.38 | T 602= | 1.03 | T 603= | 0.97 |
| T 604= | 0.75 | T 605= | 19.60 | T 606= | 19.24 | T 607= | 19.25 |
| T 608= | 19.26 | T 609= | 19.79 | T 610= | 19.59 | T 611= | 19.39 |
| T 612= | 19.33 | T 613= | 18.55 | T 614= | 3.13 | T 615= | 2.51 |
| T 616= | 1.54 | T 617= | 0.87 | T 618= | 0.97 | T 501= | 4.19 |
| T 502= | 3.89 | T 503= | 3.62 | T 504= | 3.19 | T 505= | 15.90 |
| T 506= | 15.62 | T 507= | 15.37 | T 508= | 14.53 | T 509= | 15.54 |
| T 510= | 15.32 | T 511= | 15.20 | T 512= | 15.29 | T 513= | 14.24 |
| T 514= | 5.94 | T 515= | 5.68 | T 516= | 5.08 | T 517= | 4.29 |
| T 518= | 4.44 | T 401= | 6.91 | T 402= | 6.69 | T 403= | 6.21 |
| T 404= | 5.58 | T 405= | 12.30 | T 406= | 12.05 | T 407= | 11.54 |
| T 408= | 9.94 | T 409= | 11.44 | T 410= | 11.26 | T 411= | 11.16 |
| T 412= | 11.34 | T 413= | 10.08 | T 414= | 8.62 | T 415= | 8.66 |
| T 416= | 8.47 | T 417= | 7.62 | T 418= | 7.77 | T 301= | 6.31 |
| T 302= | 6.10 | T 303= | 5.67 | T 304= | 4.99 | T 305= | 12.30 |
| T 306= | 12.06 | T 307= | 11.54 | T 308= | 9.94 | T 309= | 11.44 |
| T 310= | 11.26 | T 311= | 11.17 | T 312= | 11.34 | T 313= | 10.08 |
| T 314= | 7.52 | T 315= | 7.50 | T 316= | 7.42 | T 317= | 6.66 |
| T 318= | 6.78 | T 201= | 5.70 | T 202= | 5.51 | T 203= | 5.13 |
| T 204= | 4.39 | T 205= | 12.30 | T 206= | 12.06 | T 207= | 11.54 |
| T 208= | 9.94 | T 209= | 11.44 | T 210= | 11.26 | T 211= | 11.17 |
| T 212= | 11.34 | T 213= | 10.07 | T 214= | 6.42 | T 215= | 6.34 |
| T 216= | 6.36 | T 217= | 5.70 | T 218= | 5.79 | T 101= | 5.10 |
| T 102= | 4.93 | T 103= | 4.59 | T 104= | 3.80 | T 105= | 12.30 |
| T 106= | 12.06 | T 107= | 11.54 | T 108= | 9.94 | T 109= | 11.44 |
| T 110= | 11.26 | T 111= | 11.17 | T 112= | 11.34 | T 113= | 10.07 |
| T 114= | 5.32 | T 115= | 5.95 | T 116= | 5.31 | T 117= | 4.74 |
| T 118= | 4.80 | T 1601= | 0.88 | T 1602= | 0.86 | T 1603= | 0.97 |
| T 1604= | 1.30 | T 1605= | 18.46 | T 1606= | 18.33 | T 1607= | 18.87 |
| T 1608= | 19.28 | T 1609= | 0.88 | T 1610= | 0.86 | T 1611= | 0.96 |
| T 1612= | 1.26 | T 1613= | 20.00 | T 1614= | 20.00 | T 1615= | 20.00 |
| T 1616= | 20.00 | T 1617= | 20.00 | T 1618= | 20.00 | T 1501= | 1.90 |
| T 1502= | 1.90 | T 1503= | 2.00 | T 1504= | 2.22 | T 1505= | 11.83 |
| T 1506= | 11.79 | T 1507= | 12.10 | T 1508= | 12.28 | T 1509= | 1.97 |
| T 1510= | 1.97 | T 1511= | 2.07 | T 1512= | 2.27 | T 1513= | 20.00 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T | 1514= | 20.00 | T | 1515= | 20.00 | T | 1516= | 20.00 | T | 1517= | 20.00 |
| T | 1518= | 20.00 | T | 1401= | 2.89 | T | 1402= | 2.91 | T | 1403= | 3.00 |
| T | 1404= | 3.08 | T | 1405= | 5.39 | T | 1406= | 5.41 | T | 1407= | 5.55 |
| T | 1408= | 5.63 | T | 1409= | 3.03 | T | 1410= | 3.05 | T | 1411= | 3.14 |
| T | 1412= | 3.22 | T | 1413= | 20.00 | T | 1414= | 20.00 | T | 1415= | 20.00 |
| T | 1416= | 20.00 | T | 1417= | 20.00 | T | 1418= | 20.00 | T | 1301= | 2.72 |
| T | 1302= | 2.74 | T | 1303= | 2.82 | T | 1304= | 2.90 | T | 1305= | 5.39 |
| T | 1306= | 5.41 | T | 1307= | 5.55 | T | 1308= | 5.63 | T | 1309= | 2.83 |
| T | 1310= | 2.85 | T | 1311= | 2.94 | T | 1312= | 3.02 | T | 1313= | 20.00 |
| T | 1314= | 20.00 | T | 1315= | 20.00 | T | 1316= | 20.00 | T | 1317= | 20.00 |
| T | 1318= | 20.00 | T | 1201= | 2.54 | T | 1202= | 2.56 | T | 1203= | 2.64 |
| T | 1204= | 2.72 | T | 1205= | 5.39 | T | 1206= | 5.41 | T | 1207= | 5.55 |
| T | 1208= | 5.63 | T | 1209= | 2.64 | T | 1210= | 2.66 | T | 1211= | 2.74 |
| T | 1212= | 2.82 | T | 1213= | 20.00 | T | 1214= | 20.00 | T | 1215= | 20.00 |
| T | 1216= | 20.00 | T | 1217= | 20.00 | T | 1218= | 20.00 | T | 1101= | 2.37 |
| T | 1102= | 2.38 | T | 1103= | 2.46 | T | 1104= | 2.54 | T | 1105= | 5.39 |
| T | 1106= | 5.41 | T | 1107= | 5.55 | T | 1108= | 5.63 | T | 1109= | 2.44 |
| T | 1110= | 2.46 | T | 1111= | 2.54 | T | 1112= | 2.62 | T | 1113= | 20.00 |
| T | 1114= | 20.00 | T | 1115= | 20.00 | T | 1116= | 20.00 | T | 1117= | 20.00 |
| T | 1118= | 20.00 | T | | | | | | | | |

ASCENDING NODE NUMBER : TEMPERATURE

*****************************************************************************

ITAS STEADY-STATE SOLUTION (SUCCESSIVE POINT ITERATION)
NO. OF ITERATIONS= 2588 TOTAL INPUT ENERGY (W)= 0.16400
SYSTEM ENERGY BALANCE (W)= -8.0523 ( 4909.9 %)

*****************************************************************************

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T | 1= | 0.433 | T | 2= | 0.796 | T | 3= | 0.832 | T | 4= | 0.832 |
| T | 5= | 0.770 | T | 6= | 0.124 | T | 7= | 0.563 | T | 8= | 0.438 |
| T | 9= | 0.437 | T | 10= | 0.437 | T | 11= | 0.438 | T | 12= | 0.508 |
| T | 13= | 19.791 | T | 14= | 19.587 | T | 15= | 19.386 | T | 16= | 19.329 |
| T | 17= | 18.549 | T | 18= | 3.130 | T | 19= | 2.511 | T | 20= | 1.545 |
| T | 21= | 0.869 | T | 22= | 0.968 | T | 23= | 1.381 | T | 24= | 1.030 |
| T | 25= | 0.969 | T | 26= | 0.754 | T | 27= | 19.596 | T | 28= | 19.236 |
| T | 29= | 19.254 | T | 30= | 19.265 | T | 31= | 0.876 | T | 32= | 0.858 |
| T | 33= | 0.966 | T | 34= | 1.298 | T | 35= | 18.463 | T | 36= | 18.326 |
| T | 37= | 18.872 | T | 38= | 19.277 | T | 39= | 0.885 | T | 40= | 0.858 |
| T | 41= | 0.958 | T | 42= | 1.260 | T | 101= | 5.103 | T | 102= | 4.925 |
| T | 103= | 4.595 | T | 104= | 3.798 | T | 105= | 12.301 | T | 106= | 12.056 |
| T | 107= | 11.542 | T | 108= | 9.940 | T | 109= | 11.437 | T | 110= | 11.260 |
| T | 111= | 11.166 | T | 112= | 11.344 | T | 113= | 10.075 | T | 114= | 5.318 |
| T | 115= | 5.949 | T | 116= | 5.314 | T | 117= | 4.742 | T | 118= | 4.804 |
| T | 201= | 5.705 | T | 202= | 5.513 | T | 203= | 5.134 | T | 204= | 4.393 |
| T | 205= | 12.301 | T | 206= | 12.056 | T | 207= | 11.542 | T | 208= | 9.940 |
| T | 209= | 11.437 | T | 210= | 11.260 | T | 211= | 11.166 | T | 212= | 11.344 |
| T | 213= | 10.075 | T | 214= | 6.419 | T | 215= | 6.337 | T | 216= | 6.365 |
| T | 217= | 5.700 | T | 218= | 5.795 | T | 301= | 6.307 | T | 302= | 6.100 |
| T | 303= | 5.674 | T | 304= | 4.989 | T | 305= | 12.301 | T | 306= | 12.055 |
| T | 307= | 11.542 | T | 308= | 9.939 | T | 309= | 11.438 | T | 310= | 11.260 |
| T | 311= | 11.165 | T | 312= | 11.344 | T | 313= | 10.075 | T | 314= | 7.521 |
| T | 315= | 7.501 | T | 316= | 7.415 | T | 317= | 6.658 | T | 318= | 6.785 |
| T | 401= | 6.908 | T | 402= | 6.687 | T | 403= | 6.213 | T | 404= | 5.584 |
| T | 405= | 12.301 | T | 406= | 12.055 | T | 407= | 11.542 | T | 408= | 9.939 |
| T | 409= | 11.438 | T | 410= | 11.260 | T | 411= | 11.165 | T | 412= | 11.344 |
| T | 413= | 10.075 | T | 414= | 8.622 | T | 415= | 8.664 | T | 416= | 8.465 |
| T | 417= | 7.615 | T | 418= | 7.775 | T | 501= | 4.190 | T | 502= | 3.888 |
| T | 503= | 3.620 | T | 504= | 3.195 | T | 505= | 15.904 | T | 506= | 15.618 |
| T | 507= | 15.370 | T | 508= | 14.526 | T | 509= | 15.540 | T | 510= | 15.318 |
| T | 511= | 15.195 | T | 512= | 15.285 | T | 513= | 14.240 | T | 514= | 5.939 |
| T | 515= | 5.684 | T | 516= | 5.080 | T | 517= | 4.288 | T | 518= | 4.443 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T | 601= | 1.381 | T | 602= | 1.030 | T | 603= | 0.969 | T | 604= | 0.754 |
| T | 605= | 19.596 | T | 606= | 19.235 | T | 607= | 19.254 | T | 608= | 19.265 |
| T | 609= | 19.791 | T | 610= | 19.587 | T | 611= | 19.386 | T | 612= | 19.328 |
| T | 613= | 18.549 | T | 614= | 3.129 | T | 615= | 2.510 | T | 616= | 1.545 |
| T | 617= | 0.868 | T | 618= | 0.968 | T | 901= | 0.432 | T | 902= | 0.796 |
| T | 903= | 0.832 | T | 904= | 0.831 | T | 905= | 0.769 | T | 906= | 0.124 |
| T | 907= | 0.562 | T | 908= | 0.438 | T | 909= | 0.437 | T | 910= | 0.437 |
| T | 911= | 0.437 | T | 912= | 0.508 | T | 913= | 0.000 | T | 921= | 0.501 |
| T | 922= | 0.474 | T | 923= | 0.362 | T | 924= | 0.501 | T | 925= | 0.460 |
| T | 926= | 0.362 | T | 1101= | 2.367 | T | 1102= | 2.385 | T | 1103= | 2.463 |
| T | 1104= | 2.544 | T | 1105= | 5.390 | T | 1106= | 5.409 | T | 1107= | 5.550 |
| T | 1108= | 5.629 | T | 1109= | 2.444 | T | 1110= | 2.462 | T | 1111= | 2.539 |
| T | 1112= | 2.620 | T | 1113= | 20.000 | T | 1114= | 20.000 | T | 1115= | 20.000 |
| T | 1116= | 20.000 | T | 1117= | 20.000 | T | 1118= | 20.000 | T | 1201= | 2.542 |
| T | 1202= | 2.561 | T | 1203= | 2.644 | T | 1204= | 2.724 | T | 1205= | 5.390 |
| T | 1206= | 5.409 | T | 1207= | 5.550 | T | 1208= | 5.629 | T | 1209= | 2.638 |
| T | 1210= | 2.657 | T | 1211= | 2.740 | T | 1212= | 2.820 | T | 1213= | 20.000 |
| T | 1214= | 20.000 | T | 1215= | 20.000 | T | 1216= | 20.000 | T | 1217= | 20.000 |
| T | 1218= | 20.000 | T | 1301= | 2.716 | T | 1302= | 2.736 | T | 1303= | 2.824 |
| T | 1304= | 2.904 | T | 1305= | 5.390 | T | 1306= | 5.409 | T | 1307= | 5.549 |
| T | 1308= | 5.629 | T | 1309= | 2.832 | T | 1310= | 2.853 | T | 1311= | 2.940 |
| T | 1312= | 3.020 | T | 1313= | 20.000 | T | 1314= | 20.000 | T | 1315= | 20.000 |
| T | 1316= | 20.000 | T | 1317= | 20.000 | T | 1318= | 20.000 | T | 1401= | 2.890 |
| T | 1402= | 2.912 | T | 1403= | 3.004 | T | 1404= | 3.083 | T | 1405= | 5.389 |
| T | 1406= | 5.410 | T | 1407= | 5.549 | T | 1408= | 5.628 | T | 1409= | 3.025 |
| T | 1410= | 3.048 | T | 1411= | 3.140 | T | 1412= | 3.220 | T | 1413= | 20.000 |
| T | 1414= | 20.000 | T | 1415= | 20.000 | T | 1416= | 20.000 | T | 1417= | 20.000 |
| T | 1418= | 20.000 | T | 1501= | 1.900 | T | 1502= | 1.900 | T | 1503= | 2.004 |
| T | 1504= | 2.221 | T | 1505= | 11.831 | T | 1506= | 11.788 | T | 1507= | 12.104 |
| T | 1508= | 12.278 | T | 1509= | 1.973 | T | 1510= | 1.969 | T | 1511= | 2.070 |
| T | 1512= | 2.272 | T | 1513= | 20.000 | T | 1514= | 20.000 | T | 1515= | 20.000 |
| T | 1516= | 20.000 | T | 1517= | 20.000 | T | 1518= | 20.000 | T | 1601= | 0.875 |
| T | 1602= | 0.858 | T | 1603= | 0.965 | T | 1604= | 1.298 | T | 1605= | 18.463 |
| T | 1606= | 18.325 | T | 1607= | 18.871 | T | 1608= | 19.277 | T | 1609= | 0.884 |
| T | 1610= | 0.858 | T | 1611= | 0.958 | T | 1612= | 1.260 | T | 1613= | 20.000 |
| T | 1614= | 20.000 | T | 1615= | 20.000 | T | 1616= | 20.000 | T | 1617= | 20.000 |
| T | 1618= | 20.000 | T | | | | | | | | |

ASCENDING NODE NUMBER : IMPRESSED Q

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q | 1= | 0.000 | Q | 2= | 0.000 | Q | 3= | 0.000 | Q | 4= | 0.000 |
| Q | 5= | 0.000 | Q | 6= | 0.000 | Q | 7= | 0.000 | Q | 8= | 0.000 |
| Q | 9= | 0.000 | Q | 10= | 0.000 | Q | 11= | 0.000 | Q | 12= | 0.000 |
| Q | 13= | 0.000 | Q | 14= | 0.000 | Q | 15= | 0.000 | Q | 16= | 0.000 |
| Q | 17= | 0.000 | Q | 18= | 0.000 | Q | 19= | 0.000 | Q | 20= | 0.000 |
| Q | 21= | 0.000 | Q | 22= | 0.000 | Q | 23= | 0.000 | Q | 24= | 0.000 |
| Q | 25= | 0.000 | Q | 26= | 0.000 | Q | 27= | 0.000 | Q | 28= | 0.000 |
| Q | 29= | 0.000 | Q | 30= | 0.000 | Q | 31= | 0.000 | Q | 32= | 0.000 |
| Q | 33= | 0.000 | Q | 34= | 0.000 | Q | 35= | 0.000 | Q | 36= | 0.000 |
| Q | 37= | 0.000 | Q | 38= | 0.000 | Q | 39= | 0.000 | Q | 40= | 0.000 |
| Q | 41= | 0.000 | Q | 42= | 0.000 | Q | 101= | 0.000 | Q | 102= | 0.000 |
| Q | 103= | 0.000 | Q | 104= | 0.000 | Q | 105= | 0.000 | Q | 106= | 0.000 |
| Q | 107= | 0.000 | Q | 108= | 0.000 | Q | 109= | 0.000 | Q | 110= | 0.000 |
| Q | 111= | 0.000 | Q | 112= | 0.000 | Q | 113= | 0.000 | Q | 114= | 0.000 |
| Q | 115= | 0.000 | Q | 116= | 0.000 | Q | 117= | 0.000 | Q | 118= | 0.000 |
| Q | 201= | 0.000 | Q | 202= | 0.000 | Q | 203= | 0.000 | Q | 204= | 0.000 |
| Q | 205= | 0.000 | Q | 206= | 0.000 | Q | 207= | 0.000 | Q | 208= | 0.000 |
| Q | 209= | 0.000 | Q | 210= | 0.000 | Q | 211= | 0.000 | Q | 212= | 0.000 |
| Q | 213= | 0.000 | Q | 214= | 0.000 | Q | 215= | 0.000 | Q | 216= | 0.000 |
| Q | 217= | 0.000 | Q | 218= | 0.000 | Q | 301= | 0.000 | Q | 302= | 0.000 |
| Q | 303= | 0.000 | Q | 304= | 0.000 | Q | 305= | 0.000 | Q | 306= | 0.000 |
| Q | 307= | 0.000 | Q | 308= | 0.000 | Q | 309= | 0.000 | Q | 310= | 0.000 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q | 311= | 0.000 | Q | 312= | 0.000 | Q | 313= | 0.000 | Q | 314= | 0.000 |
| Q | 315= | 0.000 | Q | 316= | 0.000 | Q | 317= | 0.000 | Q | 318= | 0.000 |
| Q | 401= | 0.003 | Q | 402= | 0.004 | Q | 403= | 0.001 | Q | 404= | 0.001 |
| Q | 405= | 0.000 | Q | 406= | 0.000 | Q | 407= | 0.000 | Q | 408= | 0.000 |
| Q | 409= | 0.000 | Q | 410= | 0.000 | Q | 411= | 0.000 | Q | 412= | 0.000 |
| Q | 413= | 0.000 | Q | 414= | 0.000 | Q | 415= | 0.000 | Q | 416= | 0.000 |
| Q | 417= | 0.000 | Q | 418= | 0.000 | Q | 501= | 0.000 | Q | 502= | 0.000 |
| Q | 503= | 0.000 | Q | 504= | 0.000 | Q | 505= | 0.000 | Q | 506= | 0.000 |
| Q | 507= | 0.000 | Q | 508= | 0.000 | Q | 509= | 0.000 | Q | 510= | 0.000 |
| Q | 511= | 0.000 | Q | 512= | 0.000 | Q | 513= | 0.000 | Q | 514= | 0.000 |
| Q | 515= | 0.000 | Q | 516= | 0.000 | Q | 517= | 0.000 | Q | 518= | 0.000 |
| Q | 601= | 0.058 | Q | 602= | 0.070 | Q | 603= | 0.026 | Q | 604= | 0.001 |
| Q | 605= | 0.000 | Q | 606= | 0.000 | Q | 607= | 0.000 | Q | 608= | 0.000 |
| Q | 609= | 0.000 | Q | 610= | 0.000 | Q | 611= | 0.000 | Q | 612= | 0.000 |
| Q | 613= | 0.000 | Q | 614= | 0.000 | Q | 615= | 0.000 | Q | 616= | 0.000 |
| Q | 617= | 0.000 | Q | 618= | 0.000 | Q | 901= | 0.000 | Q | 902= | 0.000 |
| Q | 903= | 0.000 | Q | 904= | 0.000 | Q | 905= | 0.000 | Q | 906= | 0.000 |
| Q | 907= | 0.000 | Q | 908= | 0.000 | Q | 909= | 0.000 | Q | 910= | 0.000 |
| Q | 911= | 0.000 | Q | 912= | 0.000 | Q | 913= | 0.000 | Q | 921= | 0.000 |
| Q | 922= | 0.000 | Q | 923= | 0.000 | Q | 924= | 0.000 | Q | 925= | 0.000 |
| Q | 926= | 0.000 | Q | 1101= | 0.000 | Q | 1102= | 0.000 | Q | 1103= | 0.000 |
| Q | 1104= | 0.000 | Q | 1105= | 0.000 | Q | 1106= | 0.000 | Q | 1107= | 0.000 |
| Q | 1108= | 0.000 | Q | 1109= | 0.000 | Q | 1110= | 0.000 | Q | 1111= | 0.000 |
| Q | 1112= | 0.000 | Q | 1113= | 0.000 | Q | 1114= | 0.000 | Q | 1115= | 0.000 |
| Q | 1116= | 0.000 | Q | 1117= | 0.000 | Q | 1118= | 0.000 | Q | 1201= | 0.000 |
| Q | 1202= | 0.000 | Q | 1203= | 0.000 | Q | 1204= | 0.000 | Q | 1205= | 0.000 |
| Q | 1206= | 0.000 | Q | 1207= | 0.000 | Q | 1208= | 0.000 | Q | 1209= | 0.000 |
| Q | 1210= | 0.000 | Q | 1211= | 0.000 | Q | 1212= | 0.000 | Q | 1213= | 0.000 |
| Q | 1214= | 0.000 | Q | 1215= | 0.000 | Q | 1216= | 0.000 | Q | 1217= | 0.000 |
| Q | 1218= | 0.000 | Q | 1301= | 0.000 | Q | 1302= | 0.000 | Q | 1303= | 0.000 |
| Q | 1304= | 0.000 | Q | 1305= | 0.000 | Q | 1306= | 0.000 | Q | 1307= | 0.000 |
| Q | 1308= | 0.000 | Q | 1309= | 0.000 | Q | 1310= | 0.000 | Q | 1311= | 0.000 |
| Q | 1312= | 0.000 | Q | 1313= | 0.000 | Q | 1314= | 0.000 | Q | 1315= | 0.000 |
| Q | 1316= | 0.000 | Q | 1317= | 0.000 | Q | 1318= | 0.000 | Q | 1401= | 0.000 |
| Q | 1402= | 0.000 | Q | 1403= | 0.000 | Q | 1404= | 0.000 | Q | 1405= | 0.000 |
| Q | 1406= | 0.000 | Q | 1407= | 0.000 | Q | 1408= | 0.000 | Q | 1409= | 0.000 |
| Q | 1410= | 0.000 | Q | 1411= | 0.000 | Q | 1412= | 0.000 | Q | 1413= | 0.000 |
| Q | 1414= | 0.000 | Q | 1415= | 0.000 | Q | 1416= | 0.000 | Q | 1417= | 0.000 |
| Q | 1418= | 0.000 | Q | 1501= | 0.000 | Q | 1502= | 0.000 | Q | 1503= | 0.000 |
| Q | 1504= | 0.000 | Q | 1505= | 0.000 | Q | 1506= | 0.000 | Q | 1507= | 0.000 |
| Q | 1508= | 0.000 | Q | 1509= | 0.000 | Q | 1510= | 0.000 | Q | 1511= | 0.000 |
| Q | 1512= | 0.000 | Q | 1513= | 0.000 | Q | 1514= | 0.000 | Q | 1515= | 0.000 |
| Q | 1516= | 0.000 | Q | 1517= | 0.000 | Q | 1518= | 0.000 | Q | 1601= | 0.000 |
| Q | 1602= | 0.000 | Q | 1603= | 0.000 | Q | 1604= | 0.000 | Q | 1605= | 0.000 |
| Q | 1606= | 0.000 | Q | 1607= | 0.000 | Q | 1608= | 0.000 | Q | 1609= | 0.000 |
| Q | 1610= | 0.000 | Q | 1611= | 0.000 | Q | 1612= | 0.000 | Q | 1613= | 0.000 |
| Q | 1614= | 0.000 | Q | 1615= | 0.000 | Q | 1616= | 0.000 | Q | 1617= | 0.000 |
| Q | 1618= | 0.000 | Q | | | | | | | | |

************************************

THERMAL CALC CPU TIME (second) = 98.8100

************************************

# APPENDIX I ITAS OUTPUT FOR HOT-CASE

```
******************************************************************************
Date: 05/20/94                                              Time: 15:04:24.10
******************************************************************************
==============================================================================
                        Thermal Analysis Parameters
==============================================================================
 1.  Solution Method:1.Steady-State 2.Transient 3. (1&2).......          1
 2.  Solution Time Step ........(minutes).......................       0.10
 3.  Final Time (minutes);if <0 then no of orbs................      -1.00
 4.  Starting Temperature ......(Kelvin )......................     300.00
 5.  Temperature Print Interval (minutes)......................         20
 6.  No. of Iterations For Convergence (NLOOP).................       9999
 7.  Temperature Unit 1:K, 2:C, 3:F, 4:R.......................          2
 8.  Solution Accuracy Parameter (not used)....................        130
 9.  Solution Convergence Parameter (not used).................       1.30
10.  Solution Tolerance (ARLXCA, DRLXCA).......................    0.00100
11.  Transient Solution Stability Factor (not used)............      0.850
12.  Include User-Defined Network.......(Y/N)..................          Y
13.  Print RADK, POWER..................(Y/N)..................          N
14.  Print Transient Time/Temperature...(Y/N)..................          N
15.  Starting Temperatures Forced (No.4)(Y/N)..................          N
16.  Thermal Analyses Without Orbital Loads (Y/N)..............          Y
17.  Stand-Alone Thermal Analyzer (ITAS-Format Models).........          N
18.  No. of Isolated Cavities (RADK files).....................          0
==============================================================================


/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
                         *ITAS THERMAL ANALYSIS*
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
******************************************************************************
Date: 05/20/94                                              Time: 15:04:24.10
******************************************************************************
==============================================================================
                     View Factor Computation Parameters
==============================================================================
1. View Factor Accuracy Parameter............................2
2. Engineering Units of the Geometry Data:
   1:inch, 2:feet, 3:centimeter, 4:meter.....................1
3. View Factor Computation Without Blockage (Y/N).............N
4. Print Control Parameters:
   0:Do Not Print; 1:Print All; 2:Print All & Intervener List.0
5. View-Factor Re-Start File.................................
==============================================================================


/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
                       *ITAS VIEW FACTOR COMPUTATIONS*
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
 INPUT IS IN  INCHES
 OUTPUT IS IN CENTIMETERS
 TOTAL SURFACES IN THIS MODEL=    42


  UNITY MINUS THE SUM OF THE FACTORS
       (VIEW FACTOR -to- SPACE)

    SURFACE        1.-FACT      KEY
```

```
         1.01        0.3965    (    3)
         1.02        0.3648    (   25)
         1.03        0.3930    (   26)
         1.04        0.3858    (   27)
         1.05        0.3524    (   28)
         1.06        0.8752    (    1)
         1.07        0.3811    (    4)
         1.08        0.3527    (   29)
         1.09        0.3855    (   30)
         1.10        0.3854    (   31)
         1.11        0.3524    (   32)
         1.12       -0.0024    (    2)
         2.01        0.6859    (   42)
         2.02        0.8949    (   40)
         2.03        0.9450    (   37)
         2.04        0.9497    (   33)
         2.05        0.8709    (   20)
         2.06        0.5751    (   41)
         2.07        0.7484    (   39)
         2.08        0.7874    (   36)
         2.09        0.7810    (   22)
         2.10        0.7203    (   18)
         3.01        0.7066    (   23)
         3.02        0.8437    (   16)
         3.03        0.8486    (   15)
         3.04        0.7683    (   12)
         3.05        0.7970    (   21)
         3.06        0.9587    (   14)
         3.07        0.9678    (   13)
         3.08        0.8683    (   10)
         4.01       -0.0193    (    8)
         4.02       -0.0115    (    6)
         4.03       -0.0117    (   11)
         4.04       -0.0154    (   19)
         4.05       -0.0348    (   34)
         4.06       -0.0001    (   24)
         4.07       -0.0003    (   35)
         4.08        0.0000    (   38)
         4.09       -0.0171    (    7)
         4.10       -0.0116    (    5)
         4.11       -0.0118    (    9)
         4.12       -0.0112    (   17)
 ACTIVE SURFACES IN OUTPUT-    42
************************************
 VIEW FACTOR CALC CPU TIME (second) =      33.4500
************************************
 ** END OF PC-ITAS VIEW FACTOR CALCULATIONS **
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/
\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/
********************************************************************************
Date: 05/20/94                                                Time: 15:04:58.10
********************************************************************************
================================================================================
                        Script-F Control Parameters
================================================================================
1. SPACE (SINK) Node Number......................................        0
2. Cutoff Limit For Area*Script-F (Sq.cm.)....................0.5000E+00
3. Cutoff Limit For Blackbody Viewfactors.....................     0.0000
4. SPACE (SINK) Node Emissivity...............................     0.9999
5  SPACE (SINK) Node Temperature (Kelvin).....................     0.0000
```

```
6. SINDA-format RADK file to be generated (Y/N)...............        N
7. SINDA Radiation Conductor Number At Start..................   100000
8. Print control: 0:No,do not print, 1:Yes, print all.........        0
9. File name to store RADKs..................................EPS.RAD
==========================================================================
```

| Seq | Surface No | Node No | Alpha | Emiss | T/Mass | Dissip | Matr ID |
|---|---|---|---|---|---|---|---|
| 1 | 1.01 | 1 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 2 | 1.02 | 2 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 3 | 1.03 | 3 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 4 | 1.04 | 4 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 5 | 1.05 | 5 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 6 | 1.06 | 6 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 7 | 1.07 | 7 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 8 | 1.08 | 8 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 9 | 1.09 | 9 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 10 | 1.10 | 10 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 11 | 1.11 | 11 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 12 | 1.12 | 12 | 0.40 | 0.80 | 1.00 | 0.00 | 0 |
| 13 | 2.01 | 13 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 14 | 2.02 | 14 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 15 | 2.03 | 15 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 16 | 2.04 | 16 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 17 | 2.05 | 17 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 18 | 2.06 | 18 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 19 | 2.07 | 19 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 20 | 2.08 | 20 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 21 | 2.09 | 21 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 22 | 2.10 | 22 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 23 | 3.01 | 23 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 24 | 3.02 | 24 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 25 | 3.03 | 25 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 26 | 3.04 | 26 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 27 | 3.05 | 27 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 28 | 3.06 | 28 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 29 | 3.07 | 29 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 30 | 3.08 | 30 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 31 | 4.01 | 31 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 32 | 4.02 | 32 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 33 | 4.03 | 33 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 34 | 4.04 | 34 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 35 | 4.05 | 35 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 36 | 4.06 | 36 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 37 | 4.07 | 37 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 38 | 4.08 | 38 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 39 | 4.09 | 39 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 40 | 4.10 | 40 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 41 | 4.11 | 41 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |
| 42 | 4.12 | 42 | 0.00 | 0.01 | 1.00 | 0.00 | 0 |

```
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
                  *ITAS SCRIPT-F (RADK) COMPUTATIONS*
/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\
PC-ITAS SCRIPT-F CALCULATION SEGMENT:
Writing ITAS-format RADK for future use
Node#,     Temp.,    TherMass,    Power
    1      10.00       1.00       0.00 EPS HOUSING
    2      10.00       1.00       0.00 EPS HOUSING
```

| | | | | |
|---|---|---|---|---|
| 3 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 4 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 5 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 6 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 7 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 8 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 9 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 10 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 11 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 12 | 10.00 | 1.00 | 0.00 | EPS HOUSING |
| 13 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 14 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 15 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 16 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 17 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 18 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 19 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 20 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 21 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 22 | 10.00 | 1.00 | 0.00 | PCB 1-1 |
| 23 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 24 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 25 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 26 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 27 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 28 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 29 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 30 | 10.00 | 1.00 | 0.00 | PCB 1-2 |
| 31 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 32 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 33 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 34 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 35 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 36 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 37 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 38 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 39 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 40 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 41 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |
| 42 | 10.00 | 1.00 | 0.00 | PCB 2 (BOTTOM) |

| | | | | |
|---|---|---|---|---|
| RAD | 00 | 0.1295000000E+01 | 1 | 4 |
| RAD | 00 | 0.3408000000E+01 | 1 | 5 |
| RAD | 00 | 0.1231900000E+02 | 1 | 6 |
| RAD | 00 | 0.1441000000E+01 | 1 | 7 |
| RAD | 00 | 0.1166000000E+01 | 1 | 10 |
| RAD | 00 | 0.3754000000E+01 | 1 | 11 |
| RAD | 00 | 0.9037000000E+01 | 1 | 12 |
| RAD | 00 | 0.5500000000E+00 | 2 | 3 |
| RAD | 00 | 0.3313000000E+01 | 2 | 6 |
| RAD | 00 | 0.3342000000E+01 | 2 | 7 |
| RAD | 00 | 0.2634000000E+01 | 2 | 12 |
| RAD | 00 | 0.9950000000E+00 | 3 | 4 |
| RAD | 00 | 0.3602000000E+01 | 3 | 6 |
| RAD | 00 | 0.9060000000E+00 | 3 | 7 |
| RAD | 00 | 0.2767000000E+01 | 3 | 12 |
| RAD | 00 | 0.7580000000E+00 | 4 | 5 |
| RAD | 00 | 0.3602000000E+01 | 4 | 6 |
| RAD | 00 | 0.2770000000E+01 | 4 | 12 |
| RAD | 00 | 0.3314000000E+01 | 5 | 6 |
| RAD | 00 | 0.2622000000E+01 | 5 | 12 |

```
RAD      00     0.1230000000E+02          6          7
RAD      00     0.3314000000E+01          6          8
RAD      00     0.3600000000E+01          6          9
RAD      00     0.3601000000E+01          6         10
RAD      00     0.3314000000E+01          6         11
RAD      00     0.1643000000E+01          6         12
RAD      00     0.3619000000E+01          7          8
RAD      00     0.1020000000E+01          7          9
RAD      00     0.9591000000E+01          7         12
RAD      00     0.7800000000E+00          8          9
RAD      00     0.2629000000E+01          8         12
RAD      00     0.7910000000E+00          9         10
RAD      00     0.2762000000E+01          9         12
RAD      00     0.2766000000E+01         10         12
RAD      00     0.2615000000E+01         11         12
RAD      00     0.5660000000E+00         12         32
RAD      00     0.5110000000E+00         12         39
RAD      00     0.6110000000E+00         12         40

 #OF RADIATION CONDUCTANCES GENERATED=    38
*************************************
 SCRIPT-F CALC CPU TIME (second)    =    2.64000
*************************************
 ITAS THERMAL ANALYZER:
vvvvvvvvvvvvvvvvvvvvv ADDING USER NODES vvvvvvvvvvv
IPTR_N= 5022
RECORD  5022=   1    901   20        0     EPS HOUSING WALLS +X
RECORD  5023=   2    902   20        0     +Y
RECORD  5024=   3    903   20        0     +Y
RECORD  5025=   4    904   20        0     +Y
RECORD  5026=   5    905   20        0     +Y
RECORD  5027=   6    906   20        0     +Z
RECORD  5028=   7    907   20        0     -X
RECORD  5029=   8    908   20        0     -Y
RECORD  5030=   9    909   20        0     -Y
RECORD  5031=  10    910   20        0     -Y
RECORD  5032=  11    911   20        0     -Y
RECORD  5033=  12    912   20        0     -Z
RECORD  5034=  13   -913   40        0     BOUNDARY NODE TO 906
RECORD  5035=  14    921   20        0     HOUSING +Y BOTTOM RAIL
RECORD  5036=  15    922   20        0     +Y MIDDLE RAIL
RECORD  5037=  16    923   20        0     +Y TOP RAIL
RECORD  5038=  17    924   20        0     -Y BOTTOM RAIL
RECORD  5039=  18    925   20        0     -Y MIDDLE RAIL
RECORD  5040=  19    926   20        0     -Y TOP RAIL
RECORD  5041=  20    601   20        .037  TOP PCB THERMAL PLANE
RECORD  5042=  21    602   20        .0475
RECORD  5043=  22    603   20        .01995
RECORD  5044=  23    604   20        .01
RECORD  5045=  24    605   20        .011
RECORD  5046=  25    606   20        .060
RECORD  5047=  26    607   20        .011
RECORD  5048=  27    608   20        0
RECORD  5049=  28    609   20        0
RECORD  5050=  29    610   20        .008
RECORD  5051=  30    611   20        .008
RECORD  5052=  31    612   20        .011
RECORD  5053=  32    613   20        0
RECORD  5054=  33    614   20        0
RECORD  5055=  34    615   20        .009
```

| | | | | | | |
|---|---|---|---|---|---|---|
| RECORD | 5056= | 35 | 616 | 20 | .009 | |
| RECORD | 5057= | 36 | 617 | 20 | .004 | |
| RECORD | 5058= | 37 | 618 | 20 | 0 | |
| RECORD | 5059= | 38 | 501 | 20 | 0 | 5TH LAYER POLYIMIDE |
| RECORD | 5060= | 39 | 502 | 20 | 0 | |
| RECORD | 5061= | 40 | 503 | 20 | 0 | |
| RECORD | 5062= | 41 | 504 | 20 | 0 | |
| RECORD | 5063= | 42 | 505 | 20 | 0 | |
| RECORD | 5064= | 43 | 506 | 20 | 0 | |
| RECORD | 5065= | 44 | 507 | 20 | 0 | |
| RECORD | 5066= | 45 | 508 | 20 | 0 | |
| RECORD | 5067= | 46 | 509 | 20 | 0 | |
| RECORD | 5068= | 47 | 510 | 20 | 0 | |
| RECORD | 5069= | 48 | 511 | 20 | 0 | |
| RECORD | 5070= | 49 | 512 | 20 | 0 | |
| RECORD | 5071= | 50 | 513 | 20 | 0 | |
| RECORD | 5072= | 51 | 514 | 20 | 0 | |
| RECORD | 5073= | 52 | 515 | 20 | 0 | |
| RECORD | 5074= | 53 | 516 | 20 | 0 | |
| RECORD | 5075= | 54 | 517 | 20 | 0 | |
| RECORD | 5076= | 55 | 518 | 20 | | |
| RECORD | 5077= | 56 | 401 | 20 | .003 | GROUND LAYER COPPER |
| RECORD | 5078= | 57 | 402 | 20 | .004 | |
| RECORD | 5079= | 58 | 403 | 20 | .001 | |
| RECORD | 5080= | 59 | 404 | 20 | .001 | |
| RECORD | 5081= | 60 | 405 | 20 | 0 | |
| RECORD | 5082= | 61 | 406 | 20 | 0 | |
| RECORD | 5083= | 62 | 407 | 20 | 0 | |
| RECORD | 5084= | 63 | 408 | 20 | 0 | |
| RECORD | 5085= | 64 | 409 | 20 | 0 | |
| RECORD | 5086= | 65 | 410 | 20 | 0 | |
| RECORD | 5087= | 66 | 411 | 20 | 0 | |
| RECORD | 5088= | 67 | 412 | 20 | 0 | |
| RECORD | 5089= | 68 | 413 | 20 | 0 | |
| RECORD | 5090= | 69 | 414 | 20 | 0 | |
| RECORD | 5091= | 70 | 415 | 20 | 0 | |
| RECORD | 5092= | 71 | 416 | 20 | 0 | |
| RECORD | 5093= | 72 | 417 | 20 | 0 | |
| RECORD | 5094= | 73 | 418 | 20 | 0 | |
| RECORD | 5095= | 74 | 301 | 20 | 0 | 3RD LAYER POLYIMIDE |
| RECORD | 5096= | 75 | 302 | 20 | 0 | |
| RECORD | 5097= | 76 | 303 | 20 | 0 | |
| RECORD | 5098= | 77 | 304 | 20 | 0 | |
| RECORD | 5099= | 78 | 305 | 20 | 0 | |
| RECORD | 5100= | 79 | 306 | 20 | 0 | |
| RECORD | 5101= | 80 | 307 | 20 | 0 | |
| RECORD | 5102= | 81 | 308 | 20 | 0 | |
| RECORD | 5103= | 82 | 309 | 20 | 0 | |
| RECORD | 5104= | 83 | 310 | 20 | 0 | |
| RECORD | 5105= | 84 | 311 | 20 | 0 | |
| RECORD | 5106= | 85 | 312 | 20 | 0 | |
| RECORD | 5107= | 86 | 313 | 20 | 0 | |
| RECORD | 5108= | 87 | 314 | 20 | 0 | |
| RECORD | 5109= | 88 | 315 | 20 | 0 | |
| RECORD | 5110= | 89 | 316 | 20 | 0 | |
| RECORD | 5111= | 90 | 317 | 20 | 0 | |
| RECORD | 5112= | 91 | 318 | 20 | 0 | |
| RECORD | 5113= | 92 | 201 | 20 | 0 | SIGNAL LEVEL (VERY LITTLE CU) |
| RECORD | 5114= | 93 | 202 | 20 | 0 | |
| RECORD | 5115= | 94 | 203 | 20 | 0 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| RECORD | 5116= | 95 | 204 | 20 | 0 | |
| RECORD | 5117= | 96 | 205 | 20 | 0 | |
| RECORD | 5118= | 97 | 206 | 20 | 0 | |
| RECORD | 5119= | 98 | 207 | 20 | 0 | |
| RECORD | 5120= | 99 | 208 | 20 | 0 | |
| RECORD | 5121= | 100 | 209 | 20 | 0 | |
| RECORD | 5122= | 101 | 210 | 20 | 0 | |
| RECORD | 5123= | 102 | 211 | 20 | 0 | |
| RECORD | 5124= | 103 | 212 | 20 | 0 | |
| RECORD | 5125= | 104 | 213 | 20 | 0 | |
| RECORD | 5126= | 105 | 214 | 20 | 0 | |
| RECORD | 5127= | 106 | 215 | 20 | 0 | |
| RECORD | 5128= | 107 | 216 | 20 | 0 | |
| RECORD | 5129= | 108 | 217 | 20 | 0 | |
| RECORD | 5130= | 109 | 218 | 20 | 0 | |
| RECORD | 5131= | 110 | 101 | 20 | 0 | TOP LAYER POLYIMIDE |
| RECORD | 5132= | 111 | 102 | 20 | 0 | |
| RECORD | 5133= | 112 | 103 | 20 | 0 | |
| RECORD | 5134= | 113 | 104 | 20 | 0 | |
| RECORD | 5135= | 114 | 105 | 20 | 0 | |
| RECORD | 5136= | 115 | 106 | 20 | 0 | |
| RECORD | 5137= | 116 | 107 | 20 | 0 | |
| RECORD | 5138= | 117 | 108 | 20 | 0 | |
| RECORD | 5139= | 118 | 109 | 20 | 0 | |
| RECORD | 5140= | 119 | 110 | 20 | 0 | |
| RECORD | 5141= | 120 | 111 | 20 | 0 | |
| RECORD | 5142= | 121 | 112 | 20 | 0 | |
| RECORD | 5143= | 122 | 113 | 20 | 0 | |
| RECORD | 5144= | 123 | 114 | 20 | 0 | |
| RECORD | 5145= | 124 | 115 | 20 | 0 | |
| RECORD | 5146= | 125 | 116 | 20 | 0 | |
| RECORD | 5147= | 126 | 117 | 20 | 0 | |
| RECORD | 5148= | 127 | 118 | 20 | 0 | |
| RECORD | 5149= | 128 | 1601 | 20 | .113 | BOTTOM PCB THERMAL PLANE COPPER |
| RECORD | 5150= | 129 | 1602 | 20 | .086 | |
| RECORD | 5151= | 130 | 1603 | 20 | .025 | |
| RECORD | 5152= | 131 | 1604 | 20 | 0 | |
| RECORD | 5153= | 132 | 1605 | 20 | 0 | |
| RECORD | 5154= | 133 | 1606 | 20 | .175 | |
| RECORD | 5155= | 134 | 1607 | 20 | 0 | |
| RECORD | 5156= | 135 | 1608 | 20 | 0 | |
| RECORD | 5157= | 136 | 1609 | 20 | .375 | |
| RECORD | 5158= | 137 | 1610 | 20 | .105 | |
| RECORD | 5159= | 138 | 1611 | 20 | .15 | |
| RECORD | 5160= | 139 | 1612 | 20 | 0 | |
| RECORD | 5161= | 140 | 1613 | 20 | 0 | |
| RECORD | 5162= | 141 | 1614 | 20 | 0 | |
| RECORD | 5163= | 142 | 1615 | 20 | 0 | |
| RECORD | 5164= | 143 | 1616 | 20 | 0 | |
| RECORD | 5165= | 144 | 1617 | 20 | 0 | |
| RECORD | 5166= | 145 | 1618 | 20 | 0 | |
| RECORD | 5167= | 146 | 1501 | 20 | 0 | 5TH LAYER POLYIMIDE |
| RECORD | 5168= | 147 | 1502 | 20 | 0 | |
| RECORD | 5169= | 148 | 1503 | 20 | 0 | |
| RECORD | 5170= | 149 | 1504 | 20 | 0 | |
| RECORD | 5171= | 150 | 1505 | 20 | 0 | |
| RECORD | 5172= | 151 | 1506 | 20 | 0 | |
| RECORD | 5173= | 152 | 1507 | 20 | 0 | |
| RECORD | 5174= | 153 | 1508 | 20 | 0 | |
| RECORD | 5175= | 154 | 1509 | 20 | 0 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| RECORD | 5176= | 155 | 1510 | 20 | 0 | |
| RECORD | 5177= | 156 | 1511 | 20 | 0 | |
| RECORD | 5178= | 157 | 1512 | 20 | 0 | |
| RECORD | 5179= | 158 | 1513 | 20 | 0 | |
| RECORD | 5180= | 159 | 1514 | 20 | 0 | |
| RECORD | 5181= | 160 | 1515 | 20 | 0 | |
| RECORD | 5182= | 161 | 1516 | 20 | 0 | |
| RECORD | 5183= | 162 | 1517 | 20 | 0 | |
| RECORD | 5184= | 163 | 1518 | 20 | 0 | |
| RECORD | 5185= | 164 | 1401 | 20 | 0 | GROUND LAYER COPPER |
| RECORD | 5186= | 165 | 1402 | 20 | 0 | |
| RECORD | 5187= | 166 | 1403 | 20 | 0 | |
| RECORD | 5188= | 167 | 1404 | 20 | 0 | |
| RECORD | 5189= | 168 | 1405 | 20 | 0 | |
| RECORD | 5190= | 169 | 1406 | 20 | 0 | |
| RECORD | 5191= | 170 | 1407 | 20 | 0 | |
| RECORD | 5192= | 171 | 1408 | 20 | 0 | |
| RECORD | 5193= | 172 | 1409 | 20 | 0 | |
| RECORD | 5194= | 173 | 1410 | 20 | 0 | |
| RECORD | 5195= | 174 | 1411 | 20 | 0 | |
| RECORD | 5196= | 175 | 1412 | 20 | 0 | |
| RECORD | 5197= | 176 | 1413 | 20 | 0 | |
| RECORD | 5198= | 177 | 1414 | 20 | 0 | |
| RECORD | 5199= | 178 | 1415 | 20 | 0 | |
| RECORD | 5200= | 179 | 1416 | 20 | 0 | |
| RECORD | 5201= | 180 | 1417 | 20 | 0 | |
| RECORD | 5202= | 181 | 1418 | 20 | 0 | |
| RECORD | 5203= | 182 | 1301 | 20 | 0 | 3RD LAYER POLYIMIDE |
| RECORD | 5204= | 183 | 1302 | 20 | 0 | |
| RECORD | 5205= | 184 | 1303 | 20 | 0 | |
| RECORD | 5206= | 185 | 1304 | 20 | 0 | |
| RECORD | 5207= | 186 | 1305 | 20 | 0 | |
| RECORD | 5208= | 187 | 1306 | 20 | 0 | |
| RECORD | 5209= | 188 | 1307 | 20 | 0 | |
| RECORD | 5210= | 189 | 1308 | 20 | 0 | |
| RECORD | 5211= | 190 | 1309 | 20 | 0 | |
| RECORD | 5212= | 191 | 1310 | 20 | 0 | |
| RECORD | 5213= | 192 | 1311 | 20 | 0 | |
| RECORD | 5214= | 193 | 1312 | 20 | 0 | |
| RECORD | 5215= | 194 | 1313 | 20 | 0 | |
| RECORD | 5216= | 195 | 1314 | 20 | 0 | |
| RECORD | 5217= | 196 | 1315 | 20 | 0 | |
| RECORD | 5218= | 197 | 1316 | 20 | 0 | |
| RECORD | 5219= | 198 | 1317 | 20 | 0 | |
| RECORD | 5220= | 199 | 1318 | 20 | 0 | |
| RECORD | 5221= | 200 | 1201 | 20 | 0 | SIGNAL LAYER COPPER |
| RECORD | 5222= | 201 | 1202 | 20 | 0 | |
| RECORD | 5223= | 202 | 1203 | 20 | 0 | |
| RECORD | 5224= | 203 | 1204 | 20 | 0 | |
| RECORD | 5225= | 204 | 1205 | 20 | 0 | |
| RECORD | 5226= | 205 | 1206 | 20 | 0 | |
| RECORD | 5227= | 206 | 1207 | 20 | 0 | |
| RECORD | 5228= | 207 | 1208 | 20 | 0 | |
| RECORD | 5229= | 208 | 1209 | 20 | 0 | |
| RECORD | 5230= | 209 | 1210 | 20 | 0 | |
| RECORD | 5231= | 210 | 1211 | 20 | 0 | |
| RECORD | 5232= | 211 | 1212 | 20 | 0 | |
| RECORD | 5233= | 212 | 1213 | 20 | 0 | |
| RECORD | 5234= | 213 | 1214 | 20 | 0 | |
| RECORD | 5235= | 214 | 1215 | 20 | 0 | |

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RECORD  5236= 215     1216  20          0
RECORD  5237= 216     1217  20          0
RECORD  5238= 217     1218  20          0
RECORD  5239= 218     1101  20          0      TOP LAYER POLYIMIDE
RECORD  5240= 219     1102  20          0
RECORD  5241= 220     1103  20          0
RECORD  5242= 221     1104  20          0
RECORD  5243= 222     1105  20          0
RECORD  5244= 223     1106  20          0
RECORD  5245= 224     1107  20          0
RECORD  5246= 225     1108  20          0
RECORD  5247= 226     1109  20          0
RECORD  5248= 227     1110  20          0
RECORD  5249= 228     1111  20          0
RECORD  5250= 229     1112  20          0
RECORD  5251= 230     1113  20          0
RECORD  5252= 231     1114  20          0
RECORD  5253= 232     1115  20          0
RECORD  5254= 233     1116  20          0
RECORD  5255= 234     1117  20          0
RECORD  5256= 235     1118  20          0
^^^^^^^^^^^^^^^^^^^^^ END OF USER NODES ^^^^^^^^^^
^^^^^^^^^^^^^^^^^^^ END OF FLUID ^^^^^^^^^^^^^^^
 TOTAL THERMAL MASS ENCOUNTERED (W-MIN/C)=    1329.04
 TOTAL THERMAL MASS ENCOUNTERED (BTU  /F)=    42.0002
^^^^^^^^^^^^^^^^^^^ END OF FLUID ^^^^^^^^^^^^^^^^
 NODE       1 (REL NODE      1 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       2 (REL NODE      2 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       3 (REL NODE      3 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       4 (REL NODE      4 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       5 (REL NODE      5 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       6 (REL NODE      6 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       7 (REL NODE      7 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       8 (REL NODE      8 ) IS BEING ADDED TO THE CURRENT LIST
 NODE       9 (REL NODE      9 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      10 (REL NODE     10 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      11 (REL NODE     11 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      12 (REL NODE     12 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      13 (REL NODE     13 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      14 (REL NODE     14 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      15 (REL NODE     15 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      16 (REL NODE     16 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      17 (REL NODE     17 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      18 (REL NODE     18 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      19 (REL NODE     19 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      20 (REL NODE     20 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      21 (REL NODE     21 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      22 (REL NODE     22 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      23 (REL NODE     23 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      24 (REL NODE     24 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      25 (REL NODE     25 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      26 (REL NODE     26 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      27 (REL NODE     27 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      28 (REL NODE     28 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      29 (REL NODE     29 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      30 (REL NODE     30 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      31 (REL NODE     31 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      32 (REL NODE     32 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      33 (REL NODE     33 ) IS BEING ADDED TO THE CURRENT LIST
 NODE      34 (REL NODE     34 ) IS BEING ADDED TO THE CURRENT LIST
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NODE       35 (REL NODE       35 ) IS BEING ADDED TO THE CURRENT LIST
NODE       36 (REL NODE       36 ) IS BEING ADDED TO THE CURRENT LIST
NODE       37 (REL NODE       37 ) IS BEING ADDED TO THE CURRENT LIST
NODE       38 (REL NODE       38 ) IS BEING ADDED TO THE CURRENT LIST
NODE       39 (REL NODE       39 ) IS BEING ADDED TO THE CURRENT LIST
NODE       40 (REL NODE       40 ) IS BEING ADDED TO THE CURRENT LIST
NODE       41 (REL NODE       41 ) IS BEING ADDED TO THE CURRENT LIST
NODE       42 (REL NODE       42 ) IS BEING ADDED TO THE CURRENT LIST
END OF RADIATION CONDUCTANCE & POWER PROCESSING
ITAS THERMAL ANALYSIS:


CHECKOUT PHASE OF PC-ITAS THERMAL ANALYSIS

TOTAL CARDS ENCOUNTERED:    1776
TOTAL THERMAL MASSES USED (W-Min/C)=     1366.04
TOTAL THERMAL MASSES USED (BTU/F  )=     43.1695
===============================================================================
NO. OF THERMAL NODES=           277

ITAS STEADY-STATE SOLUTION ALGORITHM (SUCCESSIVE POINT ITERATION) PARAMETERS:
ARLXCA=0.10000E-02, DRLXCA=0.10000E-02 NLOOP=  9999
*******************************************************************************
ITAS STEADY-STATE SOLUTION (SUCCESSIVE POINT ITERATION)
NO. OF ITERATIONS= 2805 TOTAL INPUT ENERGY (W)=  1.2830
SYSTEM ENERGY BALANCE (W)=  7.1385     (  556.39    %)
*******************************************************************************
T       1=     39.68 T     2=     39.43 T     3=     39.39 T     4=     39.40
T       5=     39.46 T     6=     39.91 T     7=     39.61 T     8=     39.68
T       9=     39.68 T    10=     39.68 T    11=     39.68 T    12=     39.64
T      13=     20.18 T    14=     20.43 T    15=     20.66 T    16=     20.73
T      17=     21.65 T    18=     37.01 T    19=     38.08 T    20=     38.64
T      21=     39.26 T    22=     39.17 T    23=     39.02 T    24=     39.28
T      25=     39.27 T    26=     39.43 T    27=     20.59 T    28=     21.00
T      29=     20.89 T    30=     20.74 T    31=     39.39 T    32=     39.42
T      33=     39.28 T    34=     38.92 T    35=     21.45 T    36=     22.58
T      37=     21.48 T    38=     20.84 T    39=     39.71 T    40=     39.43
T      41=     39.44 T    42=     38.89 T   901=     39.68 T   902=     39.43
T     903=     39.39 T   904=     39.40 T   905=     39.46 T   906=     39.91
T     907=     39.61 T   908=     39.68 T   909=     39.68 T   910=     39.68
T     911=     39.68 T   912=     39.64 T   913=     40.00 T   921=     39.65
T     922=     39.65 T   923=     39.74 T   924=     39.54 T   925=     39.67
T     926=     39.74 T   601=     39.02 T   602=     39.28 T   603=     39.27
T     604=     39.43 T   605=     20.59 T   606=     21.00 T   607=     20.89
T     608=     20.74 T   609=     20.18 T   610=     20.43 T   611=     20.66
T     612=     20.73 T   613=     21.65 T   614=     37.01 T   615=     38.08
T     616=     38.64 T   617=     39.26 T   618=     39.17 T   501=     36.53
T     502=     36.72 T   503=     36.78 T   504=     37.12 T   505=     24.43
T     506=     24.72 T   507=     24.88 T   508=     25.64 T   509=     24.60
T     510=     24.85 T   511=     24.98 T   512=     24.88 T   513=     25.99
T     514=     34.27 T   515=     34.75 T   516=     35.15 T   517=     35.89
T     518=     35.74 T   401=     34.13 T   402=     34.21 T   403=     34.35
T     404=     34.86 T   405=     28.19 T   406=     28.39 T   407=     28.81
T     408=     30.38 T   409=     28.86 T   410=     29.04 T   411=     29.13
T     412=     28.93 T   413=     30.18 T   414=     31.66 T   415=     31.63
T     416=     31.80 T   417=     32.62 T   418=     32.45 T   301=     34.64
T     302=     34.73 T   303=     34.85 T   304=     35.41 T   305=     28.19
T     306=     28.39 T   307=     28.81 T   308=     30.38 T   309=     28.86
T     310=     29.04 T   311=     29.13 T   312=     28.93 T   313=     30.18
T     314=     32.73 T   315=     32.76 T   316=     32.83 T   317=     33.56
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| T 318= | 33.43 | T 201= | 35.16 | T 202= | 35.24 | T 203= | 35.34 |
| T 204= | 35.97 | T 205= | 28.19 | T 206= | 28.39 | T 207= | 28.81 |
| T 208= | 30.38 | T 209= | 28.86 | T 210= | 29.04 | T 211= | 29.13 |
| T 212= | 28.93 | T 213= | 30.18 | T 214= | 33.81 | T 215= | 33.90 |
| T 216= | 33.86 | T 217= | 34.50 | T 218= | 34.40 | T 101= | 35.68 |
| T 102= | 35.75 | T 103= | 35.84 | T 104= | 36.53 | T 105= | 28.19 |
| T 106= | 28.39 | T 107= | 28.81 | T 108= | 30.38 | T 109= | 28.86 |
| T 110= | 29.04 | T 111= | 29.13 | T 112= | 28.93 | T 113= | 30.18 |
| T 114= | 34.89 | T 115= | 34.28 | T 116= | 34.89 | T 117= | 35.44 |
| T 118= | 35.37 | T 1601= | 39.39 | T 1602= | 39.42 | T 1603= | 39.28 |
| T 1604= | 38.92 | T 1605= | 21.45 | T 1606= | 22.58 | T 1607= | 21.48 |
| T 1608= | 20.84 | T 1609= | 39.71 | T 1610= | 39.43 | T 1611= | 39.44 |
| T 1612= | 38.89 | T 1613= | 20.00 | T 1614= | 20.00 | T 1615= | 20.00 |
| T 1616= | 20.00 | T 1617= | 20.00 | T 1618= | 20.00 | T 1501= | 38.37 |
| T 1502= | 38.38 | T 1503= | 38.25 | T 1504= | 38.02 | T 1505= | 28.27 |
| T 1506= | 28.85 | T 1507= | 28.23 | T 1508= | 27.91 | T 1509= | 38.52 |
| T 1510= | 38.34 | T 1511= | 38.28 | T 1512= | 37.94 | T 1513= | 20.00 |
| T 1514= | 20.00 | T 1515= | 20.00 | T 1516= | 20.00 | T 1517= | 20.00 |
| T 1518= | 20.00 | T 1401= | 37.38 | T 1402= | 37.38 | T 1403= | 37.26 |
| T 1404= | 37.17 | T 1405= | 34.89 | T 1406= | 34.97 | T 1407= | 34.75 |
| T 1408= | 34.63 | T 1409= | 37.36 | T 1410= | 37.28 | T 1411= | 37.17 |
| T 1412= | 37.04 | T 1413= | 20.00 | T 1414= | 20.00 | T 1415= | 20.00 |
| T 1416= | 20.00 | T 1417= | 20.00 | T 1418= | 20.00 | T 1301= | 37.55 |
| T 1302= | 37.54 | T 1303= | 37.43 | T 1304= | 37.34 | T 1305= | 34.89 |
| T 1306= | 34.97 | T 1307= | 34.75 | T 1308= | 34.63 | T 1309= | 37.53 |
| T 1310= | 37.46 | T 1311= | 37.35 | T 1312= | 37.23 | T 1313= | 20.00 |
| T 1314= | 20.00 | T 1315= | 20.00 | T 1316= | 20.00 | T 1317= | 20.00 |
| T 1318= | 20.00 | T 1201= | 37.71 | T 1202= | 37.71 | T 1203= | 37.60 |
| T 1204= | 37.51 | T 1205= | 34.89 | T 1206= | 34.97 | T 1207= | 34.75 |
| T 1208= | 34.63 | T 1209= | 37.71 | T 1210= | 37.64 | T 1211= | 37.54 |
| T 1212= | 37.42 | T 1213= | 20.00 | T 1214= | 20.00 | T 1215= | 20.00 |
| T 1216= | 20.00 | T 1217= | 20.00 | T 1218= | 20.00 | T 1101= | 37.88 |
| T 1102= | 37.87 | T 1103= | 37.77 | T 1104= | 37.68 | T 1105= | 34.89 |
| T 1106= | 34.97 | T 1107= | 34.75 | T 1108= | 34.63 | T 1109= | 37.88 |
| T 1110= | 37.82 | T 1111= | 37.73 | T 1112= | 37.61 | T 1113= | 20.00 |
| T 1114= | 20.00 | T 1115= | 20.00 | T 1116= | 20.00 | T 1117= | 20.00 |
| T 1118= | 20.00 | T | | | | | |

ASCENDING NODE NUMBER : TEMPERATURE

*************************************************************************************

ITAS STEADY-STATE SOLUTION (SUCCESSIVE POINT ITERATION)
NO. OF ITERATIONS= 2805 TOTAL INPUT ENERGY (W)= 1.2830
SYSTEM ENERGY BALANCE (W)= 7.1385 ( 556.39 %)

*************************************************************************************

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| T 1= | 39.676 | T 2= | 39.432 | T 3= | 39.392 | T 4= | 39.400 |
| T 5= | 39.458 | T 6= | 39.911 | T 7= | 39.[illegible]12 | T 8= | 39.684 |
| T 9= | 39.684 | T 10= | 39.684 | T 11= | 39.684 | T 12= | 39.642 |
| T 13= | 20.181 | T 14= | 20.433 | T 15= | 20.655 | T 16= | 20.725 |
| T 17= | 21.649 | T 18= | 37.012 | T 19= | 38.079 | T 20= | 38.644 |
| T 21= | 39.25[illegible] | T 22= | 39.168 | T 23= | 39.018 | T 24= | 39.276 |
| T 25= | 39.272 | T 26= | 39.428 | T 27= | 20.586 | T 28= | 20.996 |
| T 29= | 20.890 | T 30= | 20.740 | T 31= | 39.393 | T 32= | 39.417 |
| T 33= | 39.280 | T 34= | 38.924 | T 35= | 21.450 | T 36= | 22.584 |
| T 37= | 21.483 | T 38= | 20.843 | T 39= | 39.710 | T 40= | 39.425 |
| T 41= | 39.436 | T 42= | 38.892 | T 101= | 35.675 | T 102= | 35.753 |
| T 103= | 35.841 | T 104= | 36.526 | T 105= | 28.187 | T 106= | 28.391 |
| T 107= | 28.807 | T 108= | 30.378 | T 109= | 28.861 | T 110= | 29.042 |
| T 111= | 29.133 | T 112= | 28.932 | T 113= | 30.184 | T 114= | 34.890 |
| T 115= | 34.280 | T 116= | 34.889 | T 117= | 35.438 | T 118= | 35.374 |
| T 201= | 35.159 | T 202= | 35.240 | T 203= | 35.344 | T 204= | 35.969 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T | 205= | 28.187 | T | 206= | 28.391 | T | 207= | 28.807 | T | 208= | 30.378 |
| T | 209= | 28.861 | T | 210= | 29.042 | T | 211= | 29.133 | T | 212= | 28.932 |
| T | 213= | 30.184 | T | 214= | 33.812 | T | 215= | 33.901 | T | 216= | 33.860 |
| T | 217= | 34.498 | T | 218= | 34.400 | T | 301= | 34.643 | T | 302= | 34.727 |
| T | 303= | 34.847 | T | 304= | 35.412 | T | 305= | 28.188 | T | 306= | 28.391 |
| T | 307= | 28.808 | T | 308= | 30.378 | T | 309= | 28.861 | T | 310= | 29.042 |
| T | 311= | 29.133 | T | 312= | 28.932 | T | 313= | 30.184 | T | 314= | 32.735 |
| T | 315= | 32.764 | T | 316= | 32.831 | T | 317= | 33.557 | T | 318= | 33.427 |
| T | 401= | 34.127 | T | 402= | 34.214 | T | 403= | 34.351 | T | 404= | 34.855 |
| T | 405= | 28.188 | T | 406= | 28.391 | T | 407= | 28.808 | T | 408= | 30.378 |
| T | 409= | 28.861 | T | 410= | 29.042 | T | 411= | 29.133 | T | 412= | 28.932 |
| T | 413= | 30.185 | T | 414= | 31.658 | T | 415= | 31.627 | T | 416= | 31.803 |
| T | 417= | 32.616 | T | 418= | 32.454 | T | 501= | 36.526 | T | 502= | 36.716 |
| T | 503= | 36.783 | T | 504= | 37.115 | T | 505= | 24.432 | T | 506= | 24.721 |
| T | 507= | 24.878 | T | 508= | 25.637 | T | 509= | 24.597 | T | 510= | 24.847 |
| T | 511= | 24.976 | T | 512= | 24.881 | T | 513= | 25.989 | T | 514= | 34.275 |
| T | 515= | 34.749 | T | 516= | 35.149 | T | 517= | 35.891 | T | 518= | 35.740 |
| T | 601= | 39.019 | T | 602= | 39.278 | T | 603= | 39.272 | T | 604= | 39.428 |
| T | 605= | 20.586 | T | 606= | 20.996 | T | 607= | 20.891 | T | 608= | 20.740 |
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| T | 613= | 21.650 | T | 614= | 37.013 | T | 615= | 38.079 | T | 616= | 38.644 |
| T | 617= | 39.259 | T | 618= | 39.168 | T | 901= | 39.676 | T | 902= | 39.432 |
| T | 903= | 39.392 | T | 904= | 39.401 | T | 905= | 39.458 | T | 906= | 39.911 |
| T | 907= | 39.612 | T | 908= | 39.685 | T | 909= | 39.685 | T | 910= | 39.685 |
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| T | 922= | 39.650 | T | 923= | 39.739 | T | 924= | 39.642 | T | 925= | 39.667 |
| T | 926= | 39.740 | T | 1101= | 37.875 | T | 1102= | 37.871 | T | 1103= | 37.773 |
| T | 1104= | 37.683 | T | 1105= | 34.893 | T | 1106= | 34.966 | T | 1107= | 34.751 |
| T | 1108= | 34.628 | T | 1109= | 37.882 | T | 1110= | 37.822 | T | 1111= | 37.727 |
| T | 1112= | 37.613 | T | 1113= | 20.000 | T | 1114= | 20.000 | T | 1115= | 20.000 |
| T | 1116= | 20.000 | T | 1117= | 20.000 | T | 1118= | 20.000 | T | 1201= | 37.711 |
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| T | 1206= | 34.966 | T | 1207= | 34.751 | T | 1208= | 34.628 | T | 1209= | 37.708 |
| T | 1210= | 37.642 | T | 1211= | 37.540 | T | 1212= | 37.423 | T | 1213= | 20.000 |
| T | 1214= | 20.000 | T | 1215= | 20.000 | T | 1216= | 20.000 | T | 1217= | 20.000 |
| T | 1218= | 20.000 | T | 1301= | 37.547 | T | 1302= | 37.543 | T | 1303= | 37.432 |
| T | 1304= | 37.340 | T | 1305= | 34.894 | T | 1306= | 34.966 | T | 1307= | 34.751 |
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| T | 1406= | 34.967 | T | 1407= | 34.752 | T | 1408= | 34.629 | T | 1409= | 37.359 |
| T | 1410= | 37.283 | T | 1411= | 37.167 | T | 1412= | 37.043 | T | 1413= | 20.000 |
| T | 1414= | 20.000 | T | 1415= | 20.000 | T | 1416= | 20.000 | T | 1417= | 20.000 |
| T | 1418= | 20.000 | T | 1501= | 38.371 | T | 1502= | 38.383 | T | 1503= | 38.252 |
| T | 1504= | 38.016 | T | 1505= | 28.272 | T | 1506= | 28.850 | T | 1507= | 28.225 |
| T | 1508= | 27.912 | T | 1509= | 38.516 | T | 1510= | 38.339 | T | 1511= | 38.280 |
| T | 1512= | 37.936 | T | 1513= | 20.000 | T | 1514= | 20.000 | T | 1515= | 20.000 |
| T | 1516= | 20.000 | T | 1517= | 20.000 | T | 1518= | 20.000 | T | 1601= | 39.393 |
| T | 1602= | 39.417 | T | 1603= | 39.280 | T | 1604= | 38.925 | T | 1605= | 21.450 |
| T | 1606= | 22.585 | T | 1607= | 21.484 | T | 1608= | 20.844 | T | 1609= | 39.711 |
| T | 1610= | 39.426 | T | 1611= | 39.436 | T | 1612= | 38.893 | T | 1613= | 20.000 |
| T | 1614= | 20.000 | T | 1615= | 20.000 | T | 1616= | 20.000 | T | 1617= | 20.000 |
| T | 1618= | 20.000 | T | | | | | | | | |

ASCENDING NODE NUMBER : IMPRESSED Q

| | | | | | | | | | | | |
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| Q | 1= | 0.000 | Q | 2= | 0.000 | Q | 3= | 0.000 | Q | 4= | 0.000 |
| Q | 5= | 0.000 | Q | 6= | 0.000 | Q | 7= | 0.000 | Q | 8= | 0.000 |
| Q | 9= | 0.000 | Q | 10= | 0.000 | Q | 11= | 0.000 | Q | 12= | 0.000 |
| Q | 13= | 0.000 | Q | 14= | 0.000 | Q | 15= | 0.000 | Q | 16= | 0.000 |
| Q | 17= | 0.000 | Q | 18= | 0.000 | Q | 19= | 0.000 | Q | 20= | 0.000 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q | 21= | 0.000 | Q | 22= | 0.000 | Q | 23= | 0.000 | Q | 24= | 0.000 |
| Q | 25= | 0.000 | Q | 26= | 0.000 | Q | 27= | 0.000 | Q | 28= | 0.000 |
| Q | 29= | 0.000 | Q | 30= | 0.000 | Q | 31= | 0.000 | Q | 32= | 0.000 |
| Q | 33= | 0.000 | Q | 34= | 0.000 | Q | 35= | 0.000 | Q | 36= | 0.000 |
| Q | 37= | 0.000 | Q | 38= | 0.000 | Q | 39= | 0.000 | Q | 40= | 0.000 |
| Q | 41= | 0.000 | Q | 42= | 0.000 | Q | 101= | 0.000 | Q | 102= | 0.000 |
| Q | 103= | 0.000 | Q | 104= | 0.000 | Q | 105= | 0.000 | Q | 106= | 0.000 |
| Q | 107= | 0.000 | Q | 108= | 0.000 | Q | 109= | 0.000 | Q | 110= | 0.000 |
| Q | 111= | 0.000 | Q | 112= | 0.000 | Q | 113= | 0.000 | Q | 114= | 0.000 |
| Q | 115= | 0.000 | Q | 116= | 0.000 | Q | 117= | 0.000 | Q | 118= | 0.000 |
| Q | 201= | 0.000 | Q | 202= | 0.000 | Q | 203= | 0.000 | Q | 204= | 0.000 |
| Q | 205= | 0.000 | Q | 206= | 0.000 | Q | 207= | 0.000 | Q | 208= | 0.000 |
| Q | 209= | 0.000 | Q | 210= | 0.000 | Q | 211= | 0.000 | Q | 212= | 0.000 |
| Q | 213= | 0.000 | Q | 214= | 0.000 | Q | 215= | 0.000 | Q | 216= | 0.000 |
| Q | 217= | 0.000 | Q | 218= | 0.000 | Q | 301= | 0.000 | Q | 302= | 0.000 |
| Q | 303= | 0.000 | Q | 304= | 0.000 | Q | 305= | 0.000 | Q | 306= | 0.000 |
| Q | 307= | 0.000 | Q | 308= | 0.000 | Q | 309= | 0.000 | Q | 310= | 0.000 |
| Q | 311= | 0.000 | Q | 312= | 0.000 | Q | 313= | 0.000 | Q | 314= | 0.000 |
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| Q | 401= | 0.003 | Q | 402= | 0.004 | Q | 403= | 0.001 | Q | 404= | 0.001 |
| Q | 405= | 0.000 | Q | 406= | 0.000 | Q | 407= | 0.000 | Q | 408= | 0.000 |
| Q | 409= | 0.000 | Q | 410= | 0.000 | Q | 411= | 0.000 | Q | 412= | 0.000 |
| Q | 413= | 0.000 | Q | 414= | 0.000 | Q | 415= | 0.000 | Q | 416= | 0.000 |
| Q | 417= | 0.000 | Q | 418= | 0.000 | Q | 501= | 0.000 | Q | 502= | 0.000 |
| Q | 503= | 0.000 | Q | 504= | 0.000 | Q | 505= | 0.000 | Q | 506= | 0.000 |
| Q | 507= | 0.000 | Q | 508= | 0.000 | Q | 509= | 0.000 | Q | 510= | 0.000 |
| Q | 511= | 0.000 | Q | 512= | 0.000 | Q | 513= | 0.000 | Q | 514= | 0.000 |
| Q | 515= | 0.000 | Q | 516= | 0.000 | Q | 517= | 0.000 | Q | 518= | 0.000 |
| Q | 601= | 0.037 | Q | 602= | 0.047 | Q | 603= | 0.020 | Q | 604= | 0.010 |
| Q | 605= | 0.011 | Q | 606= | 0.060 | Q | 607= | 0.011 | Q | 608= | 0.000 |
| Q | 609= | 0.000 | Q | 610= | 0.008 | Q | 611= | 0.008 | Q | 612= | 0.011 |
| Q | 613= | 0.000 | Q | 614= | 0.000 | Q | 615= | 0.009 | Q | 616= | 0.009 |
| Q | 617= | 0.004 | Q | 618= | 0.000 | Q | 901= | 0.000 | Q | 902= | 0.000 |
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| Q | 907= | 0.000 | Q | 908= | 0.000 | Q | 909= | 0.000 | Q | 910= | 0.000 |
| Q | 911= | 0.000 | Q | 912= | 0.000 | Q | 913= | 0.000 | Q | 921= | 0.000 |
| Q | 922= | 0.000 | Q | 923= | 0.000 | Q | 924= | 0.000 | Q | 925= | 0.000 |
| Q | 926= | 0.000 | Q | 1101= | 0.000 | Q | 1102= | 0.000 | Q | 1103= | 0.000 |
| Q | 1104= | 0.000 | Q | 1105= | 0.000 | Q | 1106= | 0.000 | Q | 1107= | 0.000 |
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| Q | 1112= | 0.000 | Q | 1113= | 0.000 | Q | 1114= | 0.000 | Q | 1115= | 0.000 |
| Q | 1116= | 0.000 | Q | 1117= | 0.000 | Q | 1118= | 0.000 | Q | 1201= | 0.000 |
| Q | 1202= | 0.000 | Q | 1203= | 0.000 | Q | 1204= | 0.000 | Q | 1205= | 0.000 |
| Q | 1206= | 0.000 | Q | 1207= | 0.000 | Q | 1208= | 0.000 | Q | 1209= | 0.000 |
| Q | 1210= | 0.000 | Q | 1211= | 0.000 | Q | 1212= | 0.000 | Q | 1213= | 0.000 |
| Q | 1214= | 0.000 | Q | 1215= | 0.000 | Q | 1216= | 0.000 | Q | 1217= | 0.000 |
| Q | 1218= | 0.000 | Q | 1301= | 0.000 | Q | 1302= | 0.000 | Q | 1303= | 0.000 |
| Q | 1304= | 0.000 | Q | 1305= | 0.000 | Q | 1306= | 0.000 | Q | 1307= | 0.000 |
| Q | 1308= | 0.000 | Q | 1309= | 0.000 | Q | 1310= | 0.000 | Q | 1311= | 0.000 |
| Q | 1312= | 0.000 | Q | 1313= | 0.000 | Q | 1314= | 0.000 | Q | 1315= | 0.000 |
| Q | 1316= | 0.000 | Q | 1317= | 0.000 | Q | 1318= | 0.000 | Q | 1401= | 0.000 |
| Q | 1402= | 0.000 | Q | 1403= | 0.000 | Q | 1404= | 0.000 | Q | 1405= | 0.000 |
| Q | 1406= | 0.000 | Q | 1407= | 0.000 | Q | 1408= | 0.000 | Q | 1409= | 0.000 |
| Q | 1410= | 0.000 | Q | 1411= | 0.000 | Q | 1412= | 0.000 | Q | 1413= | 0.000 |
| Q | 1414= | 0.000 | Q | 1415= | 0.000 | Q | 1416= | 0.000 | Q | 1417= | 0.000 |
| Q | 1418= | 0.000 | Q | 1501= | 0.000 | Q | 1502= | 0.000 | Q | 1503= | 0.000 |
| Q | 1504= | 0.000 | Q | 1505= | 0.000 | Q | 1506= | 0.000 | Q | 1507= | 0.000 |
| Q | 1508= | 0.000 | Q | 1509= | 0.000 | Q | 1510= | 0.000 | Q | 1511= | 0.000 |
| Q | 1512= | 0.000 | Q | 1513= | 0.000 | Q | 1514= | 0.000 | Q | 1515= | 0.000 |
| Q | 1516= | 0.000 | Q | 1517= | 0.000 | Q | 1518= | 0.000 | Q | 1601= | 0.113 |

```
Q  1602=      0.086 Q  1603=      0.025 Q  1604=      0.000 Q  1605=      0.000
Q  1606=      0.175 Q  1607=      0.000 Q  1608=      0.000 Q  1609=      0.375
Q  1610=      0.105 Q  1611=      0.150 Q  1612=      0.000 Q  1613=      0.000
Q  1614=      0.000 Q  1615=      0.000 Q  1616=      0.000 Q  1617=      0.000
Q  1618=      0.000 Q
*************************************
 THERMAL CALC CPU TIME (second)     =     100.790
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## LIST OF REFERENCES

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